=> d his

(FILE 'HOME' ENTERED AT 09:22:38 ON 12 APR 2000)

```
        FILE 'USPATFULL' ENTERED AT 09:22:40 ON 12 APR 2000
L1          15 S LEC AND ELAN
L2          14 S L1 AND ADDRESS###
L3          10 S L2 AND NAME AND SERVER
L4          10 S L2 AND NAME AND SERVER##
L5           0 S L2 AND NAME SERVER##
L6           0 S L2 AND (DOMAIN# (5A) SERVER##)
L7         322 S NAME SERVER#
L8          29 S L7 AND ATM
L9           7 S L8 AND MAC
L10         35 S ARP CACHE##
L11         35 S L10 AND ADDRESS?
```

L11   ANSWER 32 OF 35   USPATFULL
PI   US 5509123   19960416
DETD   Returning to FIG. 3B, the forwarding information base 233' is connected
        to each of a plurality of "protocol" forwarding engines 234' which are
        further illustrated in FIG. 3E. The protocol forwarding engine object
        234' includes a forward and service object 239' connected to each of an
        access list object 240', a next-hop cache object 241', and a framing
        object 242'. The framing object 242' is connected to each of
    address cache object 243' and network interface object 237'. The
        next-hop cache object 241' is connected to the network forwarding table
        object 233', or FIB in FIG. 3B. Returning to FIG. 3B, each network
        interface object 237' is connected below to a network media device
        driver 238'.
DETD   In this prior model, each protocol always gets the packet and then
        decides if it was appropriate for the interface. It is a centralized
        model with the protocol layer being the funnel for all packets entering
        and exiting the system regardless of the interface the packet came in
        on. Also, because it is centralized, each layer must have knowledge
        about every specific interface. For example, all configured interface
        information such as MTU size, forwarding enabled/disabled state,
        configured network addresses and masks, data-link framing
        options, filter access lists, etc, must be accessed by each layer as it
        processes/forwards the packet. This model puts overhead into each layer
        and is very limiting in supporting new interfaces, media, and
protocols,
        as each layer must be modified. An example of overhead is that if a
        packet is received for a protocol that is not enabled, it is not
dropped
        until it has been passed up to the correct protocol layer.
DETD   In order to provide a consistent-forwarding model for packets destined
        for "local" delivery into the "host" CPU, the host is treated as an
        internal interface with a destination address. The delivery of
        host destination packets remains in band to the forwarding function.
DETD   The operation of the forwarding engine can now be described with regard
        to FIG. 4. In response to receipt of a data packet on interface
object-1
        (11), the interface object 11 calls a service method in its bound
        forwarding engine object 12. The service method removes the sublayer
        framing on the network packet and performs a validation and extraction
        of the destination network address from the network packet.
        The service method then provides a next-hop determination by looking up
        the destination network address in a cache memory of active
    addresses to determine a destination forwarding engine object
        handle, and, if the destination network address is not located
        in cache memory, accessing a forward look-up table 20 for the best
route
        to the destination network address, and then updating its
        cache. The method then returns the destination forwarding engine object
        handle.
DETD   Assuming the destination is interface N, upon receipt of the
destination
        forwarding engine object handle, a service method is called in the
        destination forwarding engine object 15. The service method validates
        the destination address, performs a look-up in an
    address cache to obtain a media specific address of
        the destination, and the service method then reframes the packet and

DETD   transfers it to the destination interface 14.

DETD   The forwarding engines of this invention are implemented using object-orientated methodology and are written in the language C++. By having C++ objects, each forwarding engine has its own data portion 13, 16, 19 that is specific to itself, e.g., interface and media information, **address** resolution tables, configuration information, etc. However, the method portion 12, 15, 18 of each engine is common and is shared by all similar engines.

DETD   converting network layer **address** to physical **address**

DETD   The same concept holds true on the forwarding side. Each protocol FAS registers itself with the forwarding table for that protocol. This is done by registering its network **address** and masks along with a pointer to its base class with the internal forwarding table. This table is used by the service method of each protocol FAS to determine which FAS should be invoked to forward the packet, i.e.,

DETD   FAS.sub.-- ptr=Forwarding Table.sub.-- Lookup (Destination.sub.-- Network.sub.-- **Address**);

DETD   Routers must make a forwarding decision for every packet received as to what interface and next hop gateway to forward to. The decision is laborious because a number of competing route choices exist in the Forwarding Information Base (FIB), and the best route must be selected based on **address** match, metrics, quality of service, route type or class, network versus subnet granularity, etc. Once the route decision is made, it is common in router applications to cache that choice to speed up the decision for later packets having the same destination. How this caching is implemented varies wildly but is typically kept of small fixed size and is feature poor.

DETD   This invention comprises an object-oriented and feature-rich caching to provide a short-cut handling for later packets received with the same source and destination **addresses**. A separate cache exists for each network interface by containing cache objects in each forwarding engine (see for example next-hop cache object 241' and **address** cache object 243' in FIG. 3E).

DETD   This invention provides a base class ACache which is protocol independent. **Addresses** are kept as unsigned long integers. ACache does not support management set static entries; it is strictly dynamic. ACache supports:

DETD   Setting an entry is done by hashing the source and destination **addresses** into a one byte hash code and linking the entry into a "bucket" quickly accessible by that code. The entry itself has a generic base class as seen by ACache, but what is actually stored is a derived entry which may contain protocol-specific data. This allows each cache to function exactly the same regardless of specific protocol-derived classes.

DETD   As part of forwarding packets, the IP forwarding engine methods (1) validate packet **addresses**, (2) filter against an access list, and (3) retrieve the next hop from the FIB. These procedures are inherently slow, so the results of these procedures once obtained, such as **address** validity, are cached and corresponding procedures are provided in IPACache to lookup the same results quickly.

DETD   Martian (invalid) **addresses**

DETD   Each of these procedures is passed the source and destination **addresses** from a packet, hashes them and looks up entries linked in the "bucket" for that hash code. It checks each linked entry to see if it matches exactly both the source and the destination. If it finds a match it returns the entry data for that function. For the Martian lookup the **address** validity, yes or no, is returned. For access control lookup (see access list object 240' in FIG. 3E) an additional protocol and port parameter must be matched and permission, permit or deny, is returned. For next hop a quality of service parameter must be matched and the next hop is returned.

DETD   In general, routing applications allow network management to filter
        packets based on destination **address**, or on the combination of
        destination and source **addresses**. It is desirable that each
        interface of the router be able to maintain a separate set of filter
        instances--an access list. Most vendors use a linear mechanism and
since
        the list must be checked for each packet being forwarded, throughput
        slows down linearly as the list gets larger.
DETD   B.3.3 Wild Card **Addressing**
DETD   Although **addressing** is the protocol-specific part of the
        access list entry, all protocol FAC derived classes support some
special
        case **address** values which stand for a range of
    addresses. For example, in IP an **address** is paired
        with a mask and 0's in the mask are wild cards matching anything in the
        corresponding part of the **address**. Thus an **address**
        paired with a mask of all 0's matches everything. This is powerful--to
        filter out all packets from any source destined to a server, set the
        access list entry with the server's destination **address** and
        mask of all 1's, but use a source **address** and mask of 0's.
DETD   This provides ease of use in specifying what to filter. For example, to
        allow all packets through from one subnet and deny all packets from
        other subnets on the same network requires only two entries. Set the
        first entry to permit the good subnet and the second entry to deny all
        subnets of that network by using a wild card for the subnet and host
        portion of the **address**.
DETD   This also allows for discrimination based on interface, not just on
    address--e.g., all source A to destination B permitted on
        interface 1 but not on interface 2. This is not possible if filtering
is
        only checked on the forwarding side (unless interface is made part of
an
        entry, which is more awkward to administrate).
DETD   Standard data link framing formats and protocol identifiers, as defined
        by the standards committees, such as IEEE, IETF, are realized through
        specific Framing Objects. Data link framing and media details are
        embedded in the Framing Objects to relieve the network layer from this
        knowledge. Where required, methods are provided by the Framing Objects
        to obtain data link framing and media information in a generic manner,
        for example, to return the length and value of a data link physical
    address, obtain the length of a data link header, or obtain the
        media MTU.
DETD   Framing Object instances returned from the Framing Object Resource
class
        can be used by the network layer protocol to simultaneously support all
        valid framing formats for a specific media. Dynamic teaming of network
        stations and associated framing formats can be achieved. For example,
        the IP network layer protocol may be communicating with two IP stations
        on a directly connected ethernet segment using Ethernet Version 2
        framing for one IP station and 802.2 LLC with SNAP framing for the
        other. The Framing Object is retained in the **ARP cache**
        along with the MAC layer physical **address** to allow the IP
        network layer to map a framing format, as well as, a physical
    address to an IP station.
DETD   _____
Name   Derived From

_____
Integer Managed Object
                    Core INTEGER, Managed
                    Object Base Class
String Managed Object
                    Core OCTET STRING,
                    Managed Object Base
                    Class
OID Managed Object

Core OBJECT
IDENTIFIER, Managed
Object Base Class
Null Managed Object
Core NULL, Managed
Object Base Class
IP   **Address** Managed Object
Core IP **Address**,
Managed Object Base
Class
Counter Managed Object
Core Counter, Managed
Object Base Class
Gauge Managed Object
Core Gauge, Managed
Object Base Class
Time Ticks Managed Object
Core Time Ticks,
Managed Object Base
Class
Static Table Managed
Core Static Table,
Object   Managed Object
Base Class
Dynamic Table Managed
Core Dynamic Table,
Object   Managed Object
Base Class

DETD   End Systems Group--contains the managed objects which control the
Address Resolution Protocol (ARP) which maps host
addresses to physical **addresses** for each router port.
DETD   The common forwarding group MIB follows the common component view with
the exception of an **Address** Table (see Table 2). If necessary,
each protocol specifically defines an **address** table. For
example, DECnet does not require configuring an **address** per
port and so the **address** table group is not present.
DETD   TABLE 2

The Forwarding Component Group

System (1)
Aggregate Counters (1)
Interfaces (2)
Config (1)
        Config Interface Table (1)
        Address Table (2)
Counters (2)
        Counters Interface Table (1)

DETD   Config Type **addressing** component resource, consists of the
protocol's network **address** table or system wide network
address.
DETD   FIB Type--This resource is a forwarding information base. Most network
protocols have them and are used by the forwarding engines to lookup
the
next hop interface of of a given network **address**. Routing
protocols use the FIB to deposit their best next hop interface of a
given network **address**. These **addresses** are learned
dynamically through protocols. There is no common MIB template for this
type.
DETD   ARP Type--This is an ARP resource (ARP=**Addressing** Resolution
Protocol). This resource is of class Interface and Component resource.

ARP is used to resolve the physical interface **address** of a given net●k **address**. This type has a co●●● MIB template defined.

DETD   Component Resources is a base class that defines the functional implementation of a component object. For example, Base Config defines the functional implementation for configuring and accessing the network **address** per interface.

CLM   What is claimed is:

17. The apparatus of claim 7, further including means for mapping a network layer **address** to a framing format, and means for mapping a physical layer **address** to a network layer **address**.

```
=> d his

        (FILE 'HOME' ENTERED AT 13:59:51 ON 12 APR 2000)

        FILE 'USPATFULL' ENTERED AT 13:59:51 ON 12 APR 2000
L1          435 S ADDRESS RESOLUTION#
L2          267 S L1 AND SERVER#
L3          108 S L2 AND ATM
L4           85 S L3 AND MAC
```

L4   ANSWER 61 OF 85   USPATFULL
PI   US 5748626 19980505
TI   **ATM** communication system with high speed connection-less
      service function
AB   **ATM** communication system capable of realizing a high speed and
      efficient datagram delivery for the connection-less communication among
      the terminals in the **ATM** network. In the system formed by a
      plurality of **ATM** networks inter-networking with each other,
      each network containing a plurality of terminals, the **ATM**
      networks with connection-less service function units for managing a
      connection-less datagram transmission are provided in the **ATM**
      networks, and the connection-less datagram transmission from each
      terminal to a destination terminal is performed by resolving a
      connection identifier for identifying an **ATM** connection
      connected to a destination side connection-less service function unit
      associated with a destination side **ATM** network containing the
      destination terminal, and transmitting datagram from said each terminal
      to the destination side connection-less service function unit through
      the **ATM** connection identified by the resolved connection
      identifier.
SUMM The present invention relates to an **ATM** (Asynchronous Transfer
      Mode) communication system with a CLSF (Connection-Less Service
      Function).

SUMM In order to provide the highly efficient and flexible communication
      services with respect to the increasing demands for the variety of
      communications such as the image communication and the high speed data
      communication, there is an eager expectation for the realization of the
      B-ISDN (Broadband-Integrated Service Digital Network), and the
      ATM exchange scheme is considered as a prospective scheme for
      actually realizing the B-ISDN.

SUMM The **ATM** exchange scheme is a scheme for realizing the
      communication service by loading data into a fixed length packet called
      cell regardless of the attributes of the data, and using this cell as a
      unit of exchange. The ITU (formerly CCITT) has formally determined this
      ATM exchange scheme as the next generation exchange scheme, and
      decided to use this **ATM** exchange scheme for realizing the
      B-ISDN. For this reason, it is highly likely that the demands for the
      next generation multi-media communication and broadband communication
      are going to be handled by constructing the public network or the local
      network based on the **ATM** exchange scheme.

SUMM In recent years, there Is a movement for applying this **ATM**
      exchange scheme to the LAN (Local Area Network) such as the Ethernet.
In
      this case, the LAN operated under the **ATM** exchange scheme will
      be referred as the **ATM-LAN**. Such an **ATM-LAN** is
      expected to have the advantages that the throughput of the LAN can be
      improved considerably, that it is suitable for the multi-media, and
that
      it is adaptive to the public network.

SUMM Now, one of the features of the **ATM** communication scheme is
      that its high speed operation realized by the hardware switching of the
      ATM cells. That is, the **ATM** network Is the
      connection-oriented (CO) network in which the virtual connection (VC)
or
      the virtual path (VP) is set up end-to-end, and the packet called cell

is delivered end-to-end by label multiplexing or label exchanging the VCs or VPs terms of their identifiers (VCI or VPI).

SUMM   The data to be delivered end-to-end is loaded in the payload section of the **ATM** cell, and the **ATM** cell is exchanged and transmitted up to the destination terminal by the hardware switching operation alone without the intervention of the software operation, where the hardware switching operation is carried out by the **ATM** switch according to the VPI/VCI (or the value of the other field such

as
       PT in the **ATM** cell header) contained in the **ATM** cell header.

SUMM   In contrast to this **ATM** communication scheme which is the connection-oriented communication scheme, the communication scheme used in the conventional data communication is the connection-less (CL) communication scheme in which the end-to-end connections are not necessarily set up, and the packet is transmitted to the destination terminal as the packet is sent out to the network by attaching the destination data as its part while some node in the network analyzes

the
       destination data and carries out the routing processing. Namely, in the connection-less communication scheme, the data transmission is realized without the procedure for setting up the connections at the terminals. In such a case, the packet to be transmitted to the destination

terminal
       in connection-less manner is called datagram and this data transmission is called the datagram transmission. Thus, in the connection-less communication scheme, the communication is realized in a form of the datagram transmission without the procedure for setting up the connections.

SUMM   In such existing terminals or terminals provided with the existing protocols, i.e., the terminal which generates the datagram and outputs it to the destination terminal/network through the **ATM** network, the datagram transmission scheme is used for the terminal to terminal communication. To this end, it is necessary for the terminal and the network to be modified to realize the function for adapting the terminal to the interface with respect to the **ATM**-LAN by replacing the usual LAN board with the **ATM** board such as the Ethernet board or by using the terminal adaptor (TA), the function for loading the datagram into the **ATM** cell somehow at the terminal, and the function to deliver the datagram to the destination terminal indicated by the destination address at the network. Here, the terminal include the gate-way between the existing LAN and the **ATM** network.

SUMM   To realize these functions, the datagram delivery scheme using the CLSF has been used conventionally. In this datagram delivery scheme, the

CLSF
       processing unit is provided within the **ATM** network, and all the datagrams are collected there once. In other words, the CLSF processing unit is connected with all the datagram terminals by PVC (Semi-Permanent VC)(or VC, VP, PVC, or PVP), and the terminal wishing

to
       transmit the datagrams assembles the **ATM** cells for all the datagrams to be transmitted, and transmits the **ATM** cells to the VC directed toward the CLSF processing unit. The CLSF processing unit then reproduces the received datagrams, and selects the VC connected to the destination address by analyzing the destination address of the datagrams, and then re-assembles the **ATM** cells for the datagrams and transmits the **ATM** cells to the selected VC. In a case the VC connected to the destination address cannot be found while there are other CLSF processing units within the network, the CLSF processing unit transmits the re-assembled **ATM** cells

to the next stage CLSF processing unit which is expected to contain the
terminal ● the destination address or w● is determined by the
routing rule in advance.

SUMM   Here, it is not absolutely necessary for the CLSF processing unit to
analyze the destination address after reproducing the datagrams, and
transmits the **ATM** cells after re-assembling the **ATM**
cells. For instance, in a case the destination address is contained in
the to cell among the **ATM** cells for the datagrams, the
destination address of the first cell alone can be analyzed and then
transmitted to the destination terminal, and then the subsequent cells
of the **ATM** cells for the datagrams can be sequentially
transmitted to that destination terminal.

SUMM   Another scheme for transmitting the datagrams to the destination
terminal is to set up the **ATM** connection, such as VC to the
destination address, and the **ATM** cells for the datagrams are
delivered through this VC. However, in this scheme, there is a serious
problem concerning the selection of the destination terminal with
respect to which the VC is to be set up. Namely, there are enormously
many terminals to which the datagrams can possibly be transmitted in
practice, and in addition the generation of the datagrams is more
bursty
compared with the speech data, etc., so that to set up the enormously
many connections is going to be a considerable waste of the network
resource.

SUMM   Furthermore, in a case of realizing the connection-less communication
in
the conventional **ATM** network, the **ATM** connection is
always terminated at the CLSF processing unit, and the protocol
processing for the upper layers above the AAL layer such as the
protocol
for the connection-less service called CLNAP (Connection-Less Network
Access Protocol) is carried out. In other words, even in a case of the
datagram transmission between the quite nearby terminals, the
ATM connection is going to be terminated once at the CLSF
processing unit. Also, in a case of the datagram transmission between
far distanced terminals, it becomes necessary to pass through a
plurality of CLSF processing units at each one of which the protocol
processing above the AAL layer must be carried out.

SUMM   In general, the protocol processing above the AAL layer such as the
CLNAP is realized by the software processing so that the processing
speed is slow compared with the processing below the AAL layer which is
usually carried out by the hardware processing. Also, it is necessary
for the CLSF processing unit to carry out the analysis of the address
data such as the network layer address data in the datagrams for not
just the transmissions to the terminals of the network supported by
that
CLSF processing unit itself but also for the transmissions to the
terminals of the network supported by the other CLSF processing unit as
well, so that the datagram transmission processing load is going to be
concentrated on the CLSF processing unit. For these reasons, it has
been
difficult to realize the high speed communication in the
connection-less
communication (datagram delivery) among the terminals of the
conventional **ATM** communication system.

SUMM   There is also an element called "bridge" which has the similar function
as the router in realizing the inter-LAN connection. In this bridge, in
contrast to the router which determines the destination LAN by
analyzing
the destination network layer address, the destination LAN is
determined

by analyzing the data link layer address (MAC address).
Namely, the bridge realizes the inter-LAN connection by analyzing the
destination MAC address of the datagram and passing the
datagram through to another LAN when the obtained MAC address
is not destines within its own LAN.

SUMM   However, in a case of the ATM-LAN, these router, bridge, and
brouter are going to terminate the connection at the layer 3 or the
layer 2 forcefully and the processing for the layer 3 and layer 2 after
the termination is most likely handled by the software processing. For
this reason, for the transmission over the LANs, the speed and the
capacity of the communication can be considerably lowered compared with
the communication within the LAN. Also, in a case of providing the
router, bridge, brouter, etc., the VP/VC cannot be set up over the LANs
because the layer processing above the ATM layer between the
end points is carried out at the routers.

SUMM   Thus, in the conventional ATM-LAN, the layer 3 (network layer)
processing must be carried out at the physical boundary of the
networks,
because the physical network boundary is the boundary of the OSI layer
2
(data link layer), and therefore the router must be provided at the
physical network boundary for this reason.

SUMM   It is therefore an object of the present invention to provide an
ATM communication system capable of realizing a high speed and
efficient datagram delivery for the connection-less communication among
the terminals in the ATM network.

SUMM   It is another object of the present invention to provide an ATM
communication system capable of setting the topology of the network
layer independently from the topology of the physical network.

SUMM   According to one aspect of the present invention there is provided an
ATM communication system, comprising: a plurality of ATM
networks inter-networking with each other, each network containing a
plurality of terminals; and connection-less service function means for
managing a connection-less datagram transmission in the ATM
networks; wherein the connection-less datagram transmission from each
terminal to a destination terminal is performed by resolving a
connection identifier for identifying an ATM connection
connected to a destination side connection-less service function means
associated with a destination side ATM network containing the
destination terminal, and transmitting datagram from said each terminal
to the destination side connection-less service function means through
the ATM connection identified by the resolved connection
identifier.

SUMM   According to another aspect of the present invention there is provided
an ATM communication system, comprising: a plurality of
ATM networks inter-networking with each other, each network
containing a plurality of terminals and the ATM networks
including a first ATM network having connection-less service
function means for managing a connection-less datagram transmission in
the ATM networks, and a second ATM network having no
connection-less service function means; inter-networking means for
inter-networking the first and second ATM networks; and
connection set up means for setting up a first ATM connection
between the connection-less service function means of the first
ATM network and the inter-networking means, and a second
ATM connection between the inter-networking means and a terminal
belonging to the second ATM network; wherein the
inter-networking means directly connects the first and second
ATM connections set up by the connection set up means at an

ATM layer, and the connection-less service function means of the
first ATM network is assigned with an address data indicating
that said connection-less service function means logically belongs to
the second ATM network at a network layer, such that the
connection-less datagram transmission from said terminal belonging to
the second ATM network is performed by using said address data
through the first and second ATM connections connected at the
ATM layer.

SUMM   According to another aspect of the present invention there is provided
        an ATM communication system, comprising: a plurality of
        ATM networks inter-networking with each other, each network
        containing a plurality of terminals and the ATM networks
        including a first ATM network having connection-less service
        function means for managing a connection-less datagram transmission in
        the ATM networks, and second and third ATM networks
        having no connection-less service function means; first
inter-networking
        means for inter-networking the first and second ATM networks;
        second inter-networking means for inter-networking the second and third
        ATM networks; and connection set up means for setting up a first
        ATM connection between the connection-less service function
        means of the first ATM network and the inter-networking means,
        a second ATM connection between the inter-networking means and
        the second inter-networking means, and a third ATM connection
        between the second inter-networking means and a terminal belonging to
        the third ATM network; wherein the inter-networking means
        directly connects the first, second, and third ATM connections
        set up by the connection set up means at an ATM layer, and the
        connection-less service function means of the first ATM
        network is assigned with an address data indicating that said
        connection-less service function means logically belongs to the third
        ATM network at a network layer, such that the connection-less
        datagram transmission from said terminal belonging to the third
        ATM network is performed by using said address data through the
        first, second, and third ATM connections connected at the
        ATM layer.

SUMM   According to another aspect of the present invention there Is provided
a
        method for ATM communication in an ATM communication
        system formed by a plurality of ATM networks inter-networking
        with each other, each network containing a plurality of terminals, the
        method comprising the steps of: providing the AIM networks with
        connection-less service function means for managing a connection-less
        datagram transmission in the ATM networks; and performing the
        connection-less datagram transmission from each terminal to a
        destination terminal by resolving a connection identifier for
        identifying an ATM connection connected to a destination side
        connection-less service function means associated with a destination
        side ATM network containing the destination terminal, and
        transmitting datagram from said each terminal to the destination side
        connection-less service function means through the ATM
        connection identified by the resolved connection identifier.

SUMM   According to another aspect of the present invention there is provided
a
        method of ATM communication in an ATM communication
        system formed by a plurality of ATM networks inter-networking
        with each other, each network containing a plurality of terminals and
        the ATM networks including a first ATM network
        having connection-less service function means for managing a
        connection-less datagram transmission in the ATM networks, and
        a second ATM network having no connection-less service
        function means, the method comprising the steps of: inter-networking
the

first and second **ATM** networks by first inter-networking means;
setting up a first **ATM** connection between the connection-less
service function means of the first **ATM** network and the
inter-networking means, and a second **ATM** connection between
the inter-networking means and a terminal belonging to the second
ATM network: directly connecting the first and second
ATM connections at an **ATM** layer by the
inter-networking means; assigning the connection-less service function
means of the first **ATM** network with an address data indicating
that said connection-less service function means logically belongs to
the second **ATM** network at a network layer, such that the
connection-less datagram transmission from said terminal belonging to
the second **ATM** network is performed by using said address data
through the first and second **ATM** connections connected at the
ATM layer.

SUMM   According to another aspect of the present invention there is provided
a
method of **ATM** communication in an **ATM** communication
system formed by a plurality of **ATM** networks inter-networking
with each other, each network containing a plurality of terminals and
the **ATM** networks including a first **ATM** network
having connection-less service function means for managing a
connection-less datagram transmission in the **ATM** networks, and
second and third **ATM** networks having no connection-less
service function means, the method comprising the steps of:
inter-networking the first and second **ATM** networks by first
inter-networking means, and the second and third **ATM** networks
by second inter-networking means; setting up a first **ATM**
connection between the connection-less service function means of the
first **ATM** network and the inter-networking means, a second
ATM connection between the inter-networking means and the second
inter-networking means, and a third **ATM** connection between the
second inter-networking means and a terminal belonging to the third
ATM network; directly connecting the first, second, and third
ATM connections at an **ATM** layer by the first and
second inter-networking means; and assigning the connection-less
service
function means of the first **ATM** network with an address data
indicating that said connection-less service function means logically
belongs to the third **ATM** network at a network layer, such that
the connection-less datagram transmission from said terminal belonging
to the third **ATM** network is performed by using said address
data through the first, second, and third **ATM** connections
connected at the **ATM** layer.

DRWD   FIG. 1 is a schematic diagram of a first type **ATM** network
block in the **ATM** communication system according to the present
invention.

DRWD   FIG. 2 is a schematic block diagram of an inter-networking unit in the
first type **ATM** network block of FIG. 1.

DRWD   FIG. 3 is a schematic diagram of a second type **ATM** network
block in the **ATM** communication system according to the present
invention.

DRWD   FIG. 4 is a schematic block diagram of an inter-networking unit in the
second type **ATM** network block of FIG. 3.

DRWD   FIG. 5 is a partial network diagram of the **ATM** communication
system according to the present invention, showing a first case of the
datagram delivery within sub-network.

DRWD   FIG. 8 is a partial network diagram of the **ATM** communication
system according to the present invention, showing an laternative
procedure for the first case of the datagram delivery within
sub-network.

DRWD   FIG. 10 is a partial network diagram of the **ATM** communication
system according to the present invention, showing a second case of the

datagram delivery within sub-network.

DRWD　FIG. 11 is a schematic overall network diagram of the **ATM**
　　communication system according to the present invention in a case of
the
　　hierarchical network topology.

DRWD　FIG. 12 is a schematic network diagram of the network of FIG. 11 for an
　　address resolution in a first case of the datagram
　　delivery to external network.

DRWD　FIG. 14 is a schematic diagram of an address space view from one
　　address resolution server in the case of the
　　datagram delivery to external network shown in FIG. 12.

DRWD　FIG. 15 is a schematic diagram of an address space view from another
　　address resolution server in the case of the
　　datagram delivery to external network shown in FIG. 12.

DRWD　FIG. 16 is a schematic network diagram of the network of FIG. 11 for an
　　alternative procedure for an **address resolution** in a
　　first case of the datagram delivery to external network.

DRWD　FIG. 17 is a schematic diagram of an address space view from one
　　address resolution server in the case of the
　　datagram delivery to external network shown in FIG. 16.

DRWD　FIG. 18 is a schematic diagram of an address space view from another
　　address resolution server in the case of the
　　datagram delivery to external network shown in FIG. 16.

DRWD　FIG. 26 is a diagram of **ATM** connections in a second case of
　　the datagram delivery to external network.

DRWD　FIG. 27 is a schematic overall network diagram of the **ATM**
　　communication system according to the present invention in a third case
　　of the datagram delivery to external network.

DRWD　FIG. 33 is a diagram of **ATM** connections in the third case of
　　the datagram delivery to external network.

DRWD　FIG. 34 is a schematic overall network diagram of the **ATM**
　　communication system according to the present invention in a case of
the
　　flat network topology.

DRWD　FIG. 39 is a diagram of **ATM** connections in the first case of
　　the datagram delivery to external network shown in FIG. 37.

DRWD　FIG. 42 is a diagram of **ATM** connections in the first case of
　　the datagram delivery to external network shown in FIG. 40.

DRWD　FIG. 46 is a diagram of **ATM** connections in the second case of
　　the datagram delivery to external network shown in FIG. 45.

DRWD　FIG. 48 is a diagram of **ATM** connections in the second case of
　　the datagram delivery to external network shown in FIG. 47.

DRWD　FIG. 49 is a schematic overall network diagram of the **ATM**
　　communication system according to the present invention in a case of a
　　large scale network architecture.

DRWD　FIG. 52 is a diagram of **ATM** connections for an exemplary data
　　transmission in a first case of the datagram delivery to external
　　network shown in the network of FIG. 50.

DRWD　FIG. 53 is a diagram of **ATM** connections for another exemplary
　　data transmission in a first case of the datagram delivery to external
　　network shown in the network of FIG. 50.

DRWD　FIG. 54 is a diagram of **ATM** connections for an exemplary data
　　transmission in a second case of the datagram delivery to external
　　network shown in the network of FIG. 50.

DRWD　FIG. 55 is a diagram of **ATM** connections for another exemplary
　　data transmission in a second case of the datagram delivery to external
　　network shown in the network of FIG. 50.

DRWD　FIG. 56 is a schematic network diagram of the **ATM**
　　communication system according to the present invention for one
　　embodiment In a case of a modified network layer topology.

DRWD　FIG. 61 is a schematic network diagram of another network configuration
　　in the **ATM** communication system according to the present
　　invention in a case of a modified network layer topology.

DRWD　FIG. 62 is a schematic network diagram of the **ATM**
　　communication system according to the present invention for an
　execution

of a routing protocol in a case of a modified network layer topology.

DRWD FIG. 64 is a schematic network diagram of the ATM
communication system according to the present invention for a
transmission of a routing data in a case of a modified network layer
topology.

DRWD FIG. 65 is a schematic network diagram of another configuration of the
ATM communication system according to the present invention for
one embodiment in a case of a modified network layer topology.

DRWD FIG. 67 is a schematic network diagram of the ATM
communication system according to the present invention for another
embodiment in a case of a modified network layer topology.

DRWD FIG. 68 is a schematic diagram of one ATM connection setting
in the ATM communication system according to the present
invention for another embodiment in a case of a modified network layer
topology.

DRWD FIG. 69 is a schematic diagram of another ATM connection
setting in the ATM communication system according to the
present invention for another embodiment in a case of a modified
network
layer topology.

DRWD FIG. 71 is a schematic diagram of one configuration of the ATM
communication system according to the present invention for carrying
out
the broadcast in a case of a modified network layer topology.

DRWD FIG. 72 is a schematic diagram of another configuration of the
ATM communication system according to the present invention for
carrying out broadcast in a case of a modified network layer topology.

DETD ATM NETWORK BLOCK CONFIGURATION

DETD The ATM communication system according to the present
invention can be constructed from one or more of the following
ATM network blocks.

DETD 1. The first type ATM network block

DETD FIG. 1 shows a first type ATM network block in the ATM
communication system according to the present invention, which
comprises
a first ATM-LAN 11 and a second ATM-LAN 12 which are
connected through an IWU (inter-networking unit) 13, where each of the
first ATM-LAN 11 and the second ATM-LAN 12 is a
local area network formed by a plurality of terminals and nodes
operated
by the ATM scheme and equipped with a connection-less service
function processing unit (CLSF) 14 or 15, respectively.

DETD In this ATM network block of FIG. 1, each ATM-LAN
has an independent address assignment policy within itself. Namely, the
right to determine VPI/VCI used within each ATM-LAN are
assigned to a VPI/VCI determination function provided within each
ATM-LAN, and this right is assigned independently for each
ATM-LAN.

DETD In a case of a presence of a data to be transmitted, regardless of
whether the destination of the data is within the same ATM-LAN
or not, a terminal and nodes within each ATM-LAN transmits
that data within the ATM-LAN by loading that data in an
ATM cell and attaching an appropriate ATM cell header.

DETD In this ATM network block of FIG. 1, the IWU 13 has a detailed
internal configuration as shown in FIG. 2 which comprises: an add/drop
processing unit 21 provided on a cell transmission path 20, a
multiplexer/demultiplexer (MUX/DEMUX) 22 having its output connected
with the add/drop processing unit 22, a call processing unit 24 and an
IWU management unit 25 which are connected with inputs of the
MUX/DDEMUX
22, and an ATM cell header conversion unit 26 also provided on
the cell transmission path 20. Here, this IWU 13 is located between the
two ATM-LANs 11 and 12 and functions to control the
inter-networking (inter-LAN connection) between these two ATM
-LANs 11 and 12.

DETD   The add/drop processing unit 21 looks up the header portion of the
        ATM cell entering to it, and in a case that cell has the
        appropriate header value, i.e., in a case that cell is a cell to be
        terminated within the IWU 13, it executes the processing for dropping
        that cell to the DEMUX 22 side, and the processing for adding the cell
        from the MUX 22 side onto the cell transmission path 20. Here, the
        add/drop processing unit 21 in this **ATM** network block of FIG.
        1 is capable of adding or dropping the cell to either one of the right
        and left directions of the cell transmission path 20.
DETD   The call processing unit 24 has basic functions for setting up, cutting
        off, changing, and managing the **ATM** connection over the IWU
        13. In addition, this call processing unit 24 may also has additional
        functions for managing the bandwidth of the **ATM** connection or
        the cell transmission path 20 within the IWU 13.
DETD   The **ATM** cell header conversion unit 26 looks up the header
        value of the cell entering to it, and in a case the header value is an
        appropriate value, it rewrites this header value (input cell header
        value) to another value (output cell header value). For this purpose,
        the **ATM** cell header conversion unit 26 has a correspondence
        table registering the input cell header values and the output cell
        header values in correspondence. This correspondence table is also
        initialized and managed by the IWU management unit 25. As this
        correspondence table contains the input cell header value which is also
        registered in the drop table mentioned above, the correspondence table
        and the drop table can be unified together into a single table easily.
DETD   In this IWU 13, the modules are connected with each other through a bus
        line (not shown), and the control from the IWU management unit 25 such
        as the changing of the setting value at each module is achieved through
        this bus line. Alternatively, the data exchange among the modules may
be
        achieved by loading the data to be exchanged into the **ATM** cell
        and exchanging the **ATM** cell among the modules, instead of
        using the bus line, if desired.
DETD   Also, the **ATM** cell header conversion unit 28 may be provided
        on both of the right and left sides of the add/drop processing unit 21
        in order to handle the **ATM** cell header conversion for the
        ATM cell flow in the right and left directions of the cell
        transmission path 20 separately. Alternatively, the add/drop processing
        unit 21 may be provided on both of the right and left sides of the
        ATM cell header conversion unit 26 in order to handle the
        add/drop processing for the **ATM** cell flow in the right and
        left directions of the cell transmission path 20 separately. In these
        cases, the functions of the IWU 13 can be made to appear symmetrical
for
        the right and left directions of the cell transmission path 20.
DETD   In this **ATM** network block of FIG. 1, the CLSF 14 (15) realizes
        the connection-less service function in which the datagram delivered
        over the IWU 13 is terminated once, and after the network layer address
        is looked up, the datagram is transmitted to the appropriate **ATM**
        connection. Thus, the **ATM** connection for the datagram delivery
        is terminated once at the CLSF 14 (15), but there is no need to
        re-assemble the datagram. That is, at the CLSF 14 (15), it is not
        necessary to make the network layer termination, and it suffices to
make
        the connection-less (CL) layer termination as considered by the CCITT.
        In this case, the appropriate **ATM** connection to which the
        datagram is transmitted from the CLSF 14 (15) is the VP/VC connected
        with the terminal/node having the looked up network layer address, or
        the VP/VC connected with the other CLSF which is expected to have the
        function of the datagram delivery to the looked up network layer
        address.
DETD   2. The second type **ATM** network block
DETD   FIG. 3 shows a second type **ATM** network block in the
        ATM communication system according to the present invention,
        which comprises a first **ATM**-LAN 131, a second **ATM**

-LAN 132, and a third **ATM**-LAN 133 which are connected through
an IWU (inter-networking unit) 134, where each of the first **ATM**
-LAN 131, the second **ATM**-LAN 132, and the third **ATM**
-LAN 133 is a local area network formed by a plurality of terminals and
nodes operated by the **ATM** scheme and equipped with a
connection-less service function processing unit (CLSF) 135, 136, or
137, respectively.

DETD   In this **ATM** network block of FIG. 3, similarly to the first
type **ATM** network block of FIG. 1 described above, each
ATM-LAN has an independent address system within itself, and in
a case of a presence of a data to be transmitted, regardless of whether
the destination of the data is within the same **ATM**-LAN or not,
a terminal and nodes within each **ATM**-LAN transmits that data
within the **ATM**-LAN by loading that data in an **ATM**
cell and attaching an appropriate **ATM** cell header.

DETD   In this **ATM** network block of FIG. 3, the IWU 134 has a
detailed internal configuration as shown in FIG. 4 which comprises: an
ATM switch 141 of N inputs and M outputs (N=M=2 in FIG. 4), a
call processing unit 143, an IWU management unit 144, input processing
units 14A and 14B for entering inputs from two other **ATM**-LANs,
and output processing units 14X and 14Y for outputting outputs to two
other **ATM**-LANs, where the **ATM** switch 141 switches
the outputs of the input processing units 14A and 14B, the call
processing unit 143, and the IWU management unit 144 into the inputs of
the output processing units 14X and 14Y, the call processing unit 143,
and the IWU management unit 144. In a general case of having more than
three **ATM**-LANs, this IWU 134 can be expanded by incorporating
more than two input processing units and the output processing units,
and functions to control the inter-networking (inter-LAN connection)
among these **ATM**-LANs.

DETD   Each of the input processing units 14A and 14B has functions to analyze
the header value such as VPI/VCI value of the **ATM** cell
entering to it, carry out the conversion of the header value if
necessary, and attaching a routing tag for enabling an appropriate
routing of the cell at the **ATM** switch 141.

DETD   The **ATM** switch 141 then carries out the routing of the cell
entered from the input processing unit 14A or 14B according to the
routing tag attached to the cell. In addition, the **ATM** switch
141 may also have the functions such as the broadcast function or the
multicast function if desired.

DETD   Each of the output processing units 14X and 14Y has functions to remove
the routing tag from the cell outputted from the **ATM** switch
141, and carries out the conversion of the reader value if necessary.
This latter **ATM** cell header conversion function is a function
required to be provided either at the input processing unit or the
output processing unit such that a set of the input processing unit and
the output processing unit can control the connection with respect to
the switching nodes and terminals within the neighboring **ATM**
-LAN, or even to the IWU 134 if necessary.

DETD   The call processing unit 143 has basic functions for setting up,
cutting
off, changing, and managing the **ATM** connection over the IWU
134, similarly to the call processing unit 24 in the configuration of
FIG. 1 described above.

DETD   In this IWU 134, the modules are connected with each other through a
bus
line (not shown), and the control from the IWU management unit 144 such
as the changing of the setting value at each module is achieved through
this bus line. Alternatively, the data exchange among the modules may
be
achieve by loading the data to be exchanged into the **ATM** cell
and exchanging the **ATM** cell among the modules, instead of
using the bus line, if desired.

DETD   In this **ATM** network block of FIG. 3, the CLSF 135 (136, 137)
realizes the connection-less service function similar to that realized

DETD   by the CLSF 14 (15) in the configuration of FIG. 1 described above.
When the communication system according the present
invention is constructed by connecting a plurality of the **ATM**
network blocks as described above, each **ATM**-LAN can be
regarded as a sub-network. Here, a scheme for the datagram delivery
between terminals within such a sub-network will be described.

DETD   1. General **ATM** network

DETD   In an exemplary sub-network 410 shown in FIG. 5 which is equipped with
the **address resolution server** (ARS) 413
and the CLSF 414 and which is connected with the external network 416
through the IWU 415, one procedure for the datagram delivery from a
terminal (TE) 411 to another terminal 412 can be carried out as
follows.

DETD   Namely, when a datagram transmission request occurs at the terminal
411,
the terminal 411 makes an **address resolution** (AR)
request for obtaining a suitable **ATM** address for the datagram
transmission to a destination terminal 412 with respect to the ARS 413
through an **ATM** connection 41A.

DETD   In response, the ARS 413 notifies an **address
resolution** (AR) response indicating VCI/VPI data or **ATM**
address (as defined by the **ATM** Forum) to be attached to the
datagram at the terminal 411 which are identifiers of an appropriate
ATM connection for the datagram transmission to the destination
terminal 412, through an **ATM** connection 41B to the terminal
411.

DETD   When this AR response is received at the terminal 411, the notified
VCI/VPI are attached to the datagram and the datagram is outputted to
the network. The outputted datagram is then directly delivered to the
destination terminal 412 through an **ATM** connection 41C
specified by the attached VCI/VPI of the datagram.

DETD   In this case, there is a need to provide full meshed **ATM**
connections among all the terminals within each sub-network. If
ATM address is replied by ARS, the terminal will establish
ATM connection for the destination terminal using the informed
ATM address.

DETD   In this procedure, the AR request can be made either whenever the
datagram transmission request has occurred, or only when an appropriate
address data for the destination terminal cannot be found in an
address resolution (AR) table provided in the terminal
411 which is a cache memory for the destination targets. In the latter
case, when the address of the destination terminal can be found in the
AR table, the procedure for making the AR request and receiving an
address resolution (AR) response from the ARS 413 can
be omitted.

DETD   Also, in this case, the terminal 411 carries out the protocol according
to the flow chart of FIG. 7, in which after the datagram transmission
request occurs at the step 431, whether the **address
resolution** is possible by using the AR table of this terminal
411 or not is checked at the step 432. If so, the datagram transmission
takes place immediately at the step 433, whereas otherwise the AR
request is made to the ARS 413 at the step 434, the AR response is
received from the ARS 413 at the step 435, and then the datagram
transmission takes place at the step 436.

DETD   It is to be noted here that the exchange of the AR request and the AR
response can be realized by using the point-to-point **ATM**
connections as shown in FIG. 5, or by using a broadcast channel.

DETD   Namely, this is a case in which the actual datagram transmission is
carried out by the CLSF 414. In this case, when a datagram transmission
request occurs at the terminal 411, the terminal 411 carries out the
address resolution to obtain the **ATM**
connection data for the datagram transmission to the destination
terminal 412 according to the AR table provided in this terminal 411.
In
a case the address data for the destination terminal 412 cannot be
found

in the AR table at the terminal 411, the terminal 411 makes the AR request ▓obtaining a suitable **ATM** addre▓for the datagram transmiss▓n to a destination terminal 412 with respect to the ARS 413 through an **ATM** connection 41A.

DETD   In response, in a case the destination terminal is a terminal in this sub-network 410, the ARS 413 notifies the AR response indicating **ATM** layer address data through an **ATM** connection 41B to the terminal 411. A case in which the destination terminal is not a terminal in this sub-network 410 will be described below.

DETD   When the **address resolution** is completed, the terminal 411 attaches the appropriate VCI/VPI either obtained from the AR table or the AR response to the cell for transmitting the datagram and the cell is outputted to the network. Here, the attached VCI/VPI are the identifiers of an **ATM** connection 441 from the terminal 411 to the CLSF 414, so that the outputted cell reaches to the CLSF 414 through this **ATM** connection 441. At the CLSF 414, the address data of the received datagram is analyzed, and the VCI/VPI of an **ATM** connection 442 for transmitting the datagram to the destination terminal 412 are attached to the cell, and the cell is outputted to the network. The outputted cell then reaches to the destination terminal 412 through the **ATM** connection 442.

DETD   In this alternative procedure, there is a need to provide star-shaped **ATM** connections from the CLSF 414 to all the terminals. Also, the exchange of the AR request and the AR response can be realized by using the point-to-point **ATM** connections as shown in FIG. 8, or by using a broadcast channel.

DETD   Here, the **address resolution** procedure at the ARS 413 can be realized by the search on the address space data (address mask) of the network. Namely, as will be described below, it suffices for the ARS 413 to analyze the network address space in which the destination terminal is present, even for the destination terminal in the external network 416, and there is no need to resolve the VCI/VPI data for making a direct access through the **ATM** connection to the destination terminal.

DETD   In this case, each network element of the sub-network 410 is assigned with VPI as indicated in FIG. 10. Here, each terminal/**server** is equivalent to have a multipoint-to-point **ATM** connection from all UNI (User Network Interface) points within the sub-network 410. In other words, when the cell attached with the VPI of the destination terminal is outputted to the network from one terminal, the cell is transmitted to the destination UNI point. For example, in order to transmit the cell to the ARS 413, the VPI to be attached to the cell is VPI.sub.413 assigned to the ARS 413.

DETD   In this case, the procedure similar to that shown in FIG. 5 described above can be realized by using the connections 46A, 46B, and 46C. Namely, the terminal 411 transmits the AR request cell with the VPI data of the VPI.sub.413 to the ARS 413. Here, the ARS 413 can recognize that the received cell is transmitted from the terminal 411 according to the VCI data or the upper layer identifier. For example, when the VPI data of the VPI1.sub.411 assigned to the terminal 411 is written in the VCI field, the ARS 413 can recognize that the cell from the terminal 411 by the **ATM** header. Alternatively, the VCI data can be the identification number for positively identifying the cell as the AR request cell for the datagram transmission.

DETD   Then, the ARS 413 carried out the **address resolution** for the destination terminal 412, and writes VPI=VPI.sub.411 in the AR response cell and outputs the AR response cell to the network. Just as in the ARS 413, the terminal 411 then recognizes that the received cell is the AR response cell according to the VCI data or the upper layer header data. Here, the AR response cell at least contains VPI.sub.412 which is the access address data for the terminal 412.

DETD   On the other hand, the procedure similar to that shown in FIG. 8

described above can be realized by using the connections 46A, 46B, 46D, and 46E. ly, the terminal 411 transmite AR request cell with
the

VPI data of the VPI.sub.413 to the ARS 413. Then, the ARS 413 carried out the **address resolution** for the destination
terminal 412, and writes VPI=VPI.sub.414 in the AR response cell and outputs the AR response cell to the network. Here, the AR response cell at least contains VPI.sub.414 which is the access address data for the CLSF 414. Also, the CLSF 414 can recognizes that the received cell is the cell for the datagram transmission from the terminal 411 according to an identification data which is either the VCI data or the upper layer header data, and this identification data may be notified from
the

ARS 411 to the terminal 411 as the data content of the AR response.

DETD The CLSF 414 then analyzes the address data of the received cell, and attaches the VPI=VPI.sub.412 for transmitting the datagram cell to the terminal 412 and outputs the cell to the network. Then, the cell is transmitted to the terminal 412 through the **ATM** connection
46E.

DETD 1. General **ATM** network: Scheme I

DETD In this case, an exemplary hierarchical network architecture is as shown
in FIG. 11 which comprises networks 471 to 475 with the inter-networking
provided by the IWUs 476 to 479, including a public network 475 connected with the network 471 through an IWU 479. Here, each of the IWUs 476 to 479 can realize the relaying of the **ATM** cells without terminating the **ATM** connection, by having a function to convert the VCI/VPI of the received cell into VCI/VPI assigned to
the
corresponding **ATM** connection in the neighboring network.

DETD FIG. 12 shows the setting of the **ATM** connections related to the **address resolution** in which the networks 471 to
474 are also equipped with the ARSs 481 to 484, respectively, each for managing the address data of the terminals or the network itself for at least one of the networks 471 to 474 to which each of which belongs, where the ARS 481 is connected with the ARSs 482 to 484 through the
ATM connections 485 to 487.

DETD FIG. 13 shows the setting of the **ATM** connections 496, 497, 498, and 49B required for transmitting the datagrams from the network 472 to the other networks 471, 472, 474, and 475, respectively, where the **ATM** connections 486, 487, and 498 are single direction
ATM connections from the IWU 476 of the network 472 to the CLSFs 491, 493, and 494, respectively, while the **ATM** connection 49B is an **ATM** connection to a CLSF (not shown) of the public network 475 which is usually set to be bidirectional. Although not
shown
in FIG. 13, the similar bidirectional **ATM** connection from each of the other networks 471, 473, and 474 to the public network 475 are also provided. Here, any of the CLSFs and the ARSs can be located at positions of the corresponding IWUs if desired. Also, each
corresponding
CLSF and ARS can be located at the identical position.

DETD For the connection-less communication cell to be transmitted from the public network 475 to any of the networks 471 to 474, there is provided a **server** (not shown) for terminating the connection-less communication (**ATM** connection) to the public network 475 once within the network 471, such that from the public network 475 side,
this
server is defied as the access point for the connection-less communication. This **server** terminates the **ATM** connection and then transmits the datagram to the destination terminal. Here, the datagram transmission from this **server** is the same as the datagram transmission from each terminal to the other terminal.

DETD (1) The terminal makes the AR request. This can be done either always
or

only in a case the **address resolution** cannot be
succeeded by the terminal itself such as a case in which a suitable
entry is present in the AR table.

DETD   (2) The terminal obtains the VCI/VPI data, which is the identifier of
the **ATM** connection, provided from the ARS in order to make
access to the destination terminal.

DETD   Here, at a time of the datagram transmission, there is no need for the
terminal to carry out the procedure for setting up a particular
connection defined in the **ATM** network.

DETD   In this case, the star-shaped **ATM** connections (bidirectional
communication channels) have been established from the ARS 481 in the
network 471 to the ARSs 482 to 484 in the networks 472 to 474,
respectively. For example, in order to obtain the VCI/VPI for
transmitting the datagram from the terminal 47A to the terminal 47D,
the
terminal 47A transmits the AR request cell having the address data of
the terminal 47D to the ARS 482 of its own network 472. The ARS 482
which received this AR request cell then recognizes that the address of
the destination terminal written in the received cell does not belongs
to its own network 472, and carries out the relaying of the AR request
cell through the already set up **ATM** connection 485 to the ARS
481 in the network 471. Alternatively, it is also possible for the ARS
482 to cache the network address data of the external network
previously
obtained and the VCI/VPI data for transmitting the cell to the
corresponding CLSF through the **ATM** connection 485 in advance.

DETD   Here, the **address resolution** at the ARS 481 is
carried out as follows. Namely, the ARS 481 has the address data
(address space data such as net/ID) of the terminals contained in its
own network 471 and the address space data for the sub-networks 472 to
474. Then, the ARS 481 analyzes the transmission target network by
comparing the address written in the received AR request cell with the
address space data for each sub-network. Here, at a time of this
comparison, it is not necessary for the ARS 481 to analyze the host
address of the destination address, and it suffices to analyze only up
to the network address.

DETD   In this manner, the ARS 481 possesses the addresses and the address
space data of the terminals belonging to the network 471 and the
sub-networks 472. 473, and 474, so as to carry out the **address
resolution**.

DETD   The address data (**ATM** layer address data) received by the ARS
482 from the ARS 481 is the data indicating the identifier (normally
VCI/VPI, but may contain the identification data for the upper layer)
of
the **ATM** connection to the CLSF in the target sub-network from
the IWU 476. For example, at a time of the datagram transmission from
the terminal 47A to the terminal 47D, the identifiers of the **ATM**
connections 495 and 497 for accessing the CLSF 494 are notified as the
AR response, whereas at a time of the datagram transmission from the
terminal 47A to the terminal 47F, the identifiers of the **ATM**
connections 495 and 496 for accessing the CLSF 491 are notified as the
AR response. Here, the ARS 482 notifies the VCI/VPI data for correctly
relaying the **ATM** connection at the IWU 476 to the terminal
47A, according to the VCI/VPI data received from the ARS 481. The
VCI/VPI data notified to the terminal 47A is then rewritten into the
other VCI/VPI at the IWU 476.

DETD   In this case, the star-shaped **ATM** connections as shown in FIG.
12 described above is formed from the ARS 481 in the network 471 to the
ARSs 482 to 484 in the networks 472 to 474, respectively, or the meshed
ATM connections as shown in FIG. 16 is formed by the ARSs 481 to
484. Each ARS obtains the address space data and the **ATM**
connection data (VCL/VPI) for the external sub-networks viewed from its
own sub-network using the **ATM** connections defined as shown in
FIG. 12 or FIG. 16. Here, FIG. 12 is in a form in which the ARS 481
functions as a master ARS, while FIG. 16 is in a distributed form in

which each ARS operates independently. In a case the number of
hierarchi levels in the network is at m three, a case of FIG. 12
to make the backbone network as the master is more appropriate.

DETD   Here, the **address resolution** at the ARS 482 is
        carried out as follows. Namely, the ARS 482 has the address data
        (address space data) of the terminals contained in its own network 472
        and the address space data for the sub-networks 471, 473, and 474.

Then,
        the ARS 482 analyzes the transmission target network by comparing the
        address written in the received AR request cell with the address space
        data for each sub-network. Here, at a time of this comparison, it is

not
        necessary for the ARS 482 to analyze the host address of the

destination
        address, and it suffices to analyze only up to the network address.

DETD   In this manner, the ARS 482 possesses the addresses and the address
        space data of the terminals belonging to the network 472 and the
        sub-networks 471, 473, and 474, so as to carry out the **address
        resolution**.

DETD   The address data (**ATM** layer) received by the ARS 482 from the
        other ARS is the data indicating the identifier (normally VCI/VPI, but
        may contain the identification data for the upper layer) of the
        ATM connection to the CLSF in the target sub-network from the
        IWU 476. For example, at a time of the datagram transmission from the
        terminal 47A to the terminal 47D, the identifiers of the **ATM**
        connections 495 and 497 for making an access to the CLSF 494 are
        notified as the AR response, whereas at a time of the datagram
        transmission from the terminal 47A to the terminal 47F, the identifiers
        of the **ATM** connections 495 and 496 for making an access to the
        CLSF 491 are notified as the AR response. Here, the ARS 482 notifies

the
        VCI/VPI data for correctly relaying the **ATM** connection at the
        IWU 476 to the terminal 47A, according to the VCI/VPI data received

from
        the other ARS. The VCI/VPI data notified to the terminal 47A is then
        rewritten into the other VCI/VPI at the IWU 476.

DETD   Among ARSs, not only the address space data exchange protocol for each
        sub-network, but also the routing protocol concerning the datagram
        transmission (connection-less communication) among the sub-networks is
        also operated. More specifically, this routing protocol carries out the
        management of the **ATM** connection setting between the IWU and
        the CLSF as shown in FIG. 13 described above. Here, the individual
        ATM connection is separated at the IWU (i.e., closed within the
        sub-network), and the **ATM** connection routing control and the
        ATM connection management (such as VCI/VPI management) are made
        by the other **ATM** connection **server** process and the
        routing **server** process, and the ARS exchanges the control
        messages with these **servers** as well as the IWU to carry out
        the management of the **ATM** connections necessary for the
        connection-less communication.

DETD   There is also a case requiring the use of the **ATM** connection
        having different route from the normally used **ATM** connection
        due to the congestion or the obstruction in the sub-network. In such a
        case, the routing control process for carrying out the management
        control of the VCI/VPI to be set up in the table of each switch as well
        as the routing table data (where the control process for carrying out
        the address management can be the other process) carries out the
        management control such that the VCI/VPI the same VCI/VPI to be shows

to
        the UNI can be maintained even when the route within the sub-network is
        changed.

DETD   Next, when the access point of the various **server** such as CLSF
        is moved, it suffices to reboot it such that the connection identifiers
        (VCI/VPI) visible from each access point becomes the same. Also, at a
        time of the reboot, with respect to the related access point, the

request message for discarding the data for the old access from the AR
table is transmitted along with the new access data if necessary. In
the
latter case, there is a need for the IWU to update the entry data in
the
table of FIG. 19, either according to the data within the transmitted
message or by executing the protocol for obtaining the new data.

DETD   Thus, it suffices for each CLSF to possess only the address data of the
terminals of the network to which that CLSF itself belongs. When the
address of the received datagram is present in its own network, the
appropriate **ATM** connection is selected and the relaying of the
datagram is carried out.

DETD   An exemplary protocol processing in a case of transmitting the datagram
from the terminal 47A to the terminal 47D is shown in FIG. 20. Namely,
the **ATM** connection is terminated at the CLSF 494 once, i.e.,
the protocol of the OSI layer 3 is terminated at the CLSF 494. The OSI
layer 3 protocol processing is carried out at the CLSF 494, and the
data
unit is transmitted to the terminal 47D using the **ATM**
connection. In this manner, at a time of the datagram transmission to
the terminal other than those of its own sub-network, the end-to-end
datagram delivery can be realized with only one **ATM** connection
termination.

DETD   In this case, the **address resolution** is carried out
as follows.

DETD   In transmitting the datagram from the terminal 47A to the terminal 47D,
when the terminal 47A does not possess the **ATM** layer address
data for transmitting the datagram to the terminal 47D, the terminal
47A
transmits the AR request cell having the address data of the terminal
47D to the ARS 482 through the **ATM** connection 571 (581). Here,
the **ATM** connection 571 (581) can be realized by either the
point-to-point connection or the broadcast connection. The ARS 482
which
received the AR request cell recognizes that the address requested by
the AR request cell does not belongs to its own network 472, so that in
the situation of FIG. 21, the ARS 482 transmits the AR request cell to
the ARS 481 through the **ATM** connection 572. Here, the
procedure for the ARS 482 to receive the AR request cell and then
transmit the AR request cell to the ARS 481 can be any of the
following.

DETD   (1) In a case the ARS is responsible for responding to all the AR
request cells generated within its network, the ARS carries out the
screening of the AR request cells first. Namely, whether the address in
the received cell is the element of the address space of its own
network
or not is checked by using the network mask, etc.. If the address
belongs to its own network, the address table is looked up and the
ATM layer address data for the appropriate terminal is returned.
On the other hand, when the address does not belongs to its own
network,
the AR request cell is transmitted to the prescribed superior ARS which
is the ARS 481 in the example of FIG. 21.

DETD   (2) In a case the ARS makes the response only to the request for
transmitting the datagram to the terminal belonging to the sub-network
other than its own network, and the response to the AR request for the
terminal within its own network is returned by the terminal to which
the
datagram is to be transmitted itself, the result differs for a case of
using the broadcast channel and a case of using the point-to-point
connection at a time of the **address resolution**. In a
case of using the broadcast channel, after the screening of the address
is carried out, the AR request cell is taken and transmitted to the
superior ARS. On the other hand, in a case of using the point-to-point
connection, the AR request cell is transmitted to the superior ARS

unconditionally in principle.

DETD   In the example of FIG. 22, the ARS 481 which received the AR request cell checks if the address in the AR request cell is contained in the addresses and the address space contained in its own network. In a case the corresponding address is not present in the address entries, it is judged as the address directed to the public network. In this example, the destination terminal is the terminal 47D, so that the ARS 471 recognizes that the address in the AR request cell is present in the address space of its own network 474 and therefore the address space data possessed by the network 474 can be used. The ARS 481 which analyzed the address of the terminal 47D returns the response indicating the VCI/VPI data of the **ATM** connection from the IWU 476 to the CLSF 494 (VCI/VPI data viewed from the IWU 476) to the ARS 482.

DETD   The ARS 482 then returns the VCI/VPI data which is the identification data of the **ATM** connection to be relayed to the **ATM** connection connected to the CLSF 494 at the IWU 476 to the terminal 47A. By using this VCI/VPI, the terminal 47A can deliver the datagram directly to the CLSF 494.

DETD   In the example of FIG. 22 in which the ARS 482 can make the **address resolution** by itself, with respect to the AR request given through the **ATM** connection 581, the AR response can be directly transmitted to the terminal 47A through the **ATM** connection 582.

DETD   The terminal 47A transmits the cell having the datagram information to the CLSF 494 through the **ATM** connection 575 (583). The IWUs 476 and 478 carries out the relaying of the **ATM** connection by rewriting the VCI/VPI data of the received cell. This processing is carried out as the **ATM** layer processing without raising it to the upper layer, so that the **ATM** connection 575 (583) passing through the IWUs 476 and 478 can be regarded as one **ATM** connection without the **ATM** terminal point.

DETD   At the CLSF 494 which is the terminal point of the **ATM** connection 575 (583), the network layer processing is carried out. The CLSF 494 carries out the analysis of the network address, and the datagram is relayed to the **ATM** connection 576 (584) and transmitted to the terminal 47D.

DETD   In this manner, there are only two **ATM** connections from the terminal 47A to the CLSF 494, and from the CLSF 494 to the terminal 47D, so that they are terminated only once.

DETD   In this case, the **ATM** layer address assignment method will be described first.

DETD   In this case, the **ATM** connections are set up such that the setting of the **ATM** connections related to the **address resolution** are as shown in FIGS. 23 to 25. Here, each of the ARS 481 to 484 is managing the address data for the terminals or the network contained in at least one of the networks 471 to 474 to which it belongs.

DETD   FIG. 23 is a case of managing the address data of each sub-network with the ARS 481 playing the leading role (of a root ARS). The VCI/VPI data are rewritten by the IWU and the relaying of the **ATM** connections is carried out. For example, the **ATM** connection from the ARS 482 to the ARS 481 is formed by the connections 591 and 592. The connection 591 has the VPI-F having VPI.sub.476-2 which is the access address (VPI) of the IWU 476 for the network 472, and the VCI-F1 having VPI.sub.482 which is the access address of the ARS 482. As for the VCI-F2, it can take an arbitrary value in principle, but it is coded such that the IWU 476 can identify the received cell as that which is to be relayed to the connection 592 from the data content of the VCI-F2. On

the other hand, the connection 592 has the VPI-F having VPI.sub.481
which is ● access address of the ARS 481 ●d the VCI-F1 having
VPI.sub.476-1 which is the access address of the IWU 476 for the
network
471. Here, in both of these connections 591 and 592, the VCI-F2 can
take
an arbitrary value in principle.

DETD   The IWU 476 analyzes the VCI/VPI data to be written into the cell of
the
connection 592 from a set of data VCI-F1 and VCI-F2 of the received
cell. Therefore, the IWU 476 has the 16 bits VCI field as the table
entry, and as a result, has the function to analyze the VCI/VPI data.
The VPI-F of the cell of the connection 592 is analyzed by the
combination of VCI-F1 and VCI-F2. To the VCI-F1, VPI.sub.476-1 is
written, while the VCI-F2 is coded as the identifier of the **ATM**
connection between the ARS 482 to the ARS 481. The value of the VCI-F2
is determined at a time of setting the **ATM** connections
(connections 591 and 592). The assignment of the VCI-F2 can be made by
the process for managing the VCI-F2 within the sub-networks (networks
471 and 472), or by the process for managing the value of the VCI-F2 at
the terminals (ARS 481 and IWU 476).

DETD   For example, the **ATM** connection 617 from the ARS 482 to the
ARS 484 is formed by the connections 6021, 6041, and 6061. The
connection 6021 has the VPI-F having VPI.sub.476-2 which is the access
address of the IWU 476 for the network 472, and the VCI-F1 having
VPI.sub.482 which is the access address of the ARS 482. The VCI-F2 is
an
identification number allocated to this connection 6021 such that this
connection 6021 can be identified by the combination of the VCI-F1 and
the VCI-F2. The connection 6061 has the VPI-F having VPI.sub.478-1
which
is the access address of the IWU 478 for the network 471, and the
VCI-F1
having VPI.sub.476-1 which is the access address of the IWU 476 for the
network 471. The VCI-F2 is a value set at a time of setting this
connection 6061. The connection 6041 has the VPI-F having VPI.sub.484
which is the access address of the ARS 484, and the VCI-F1 having
VPI.sub.478-1 which is the access address of the IWU 478 for the
network
471. The VCI-F2 is a value set at a time of setting this connection
6041.

DETD   For example, the IWU 478 analyzes the VCI/VPI data to be written into
the cell of the connection 6041 from a set of data VCI-F1 and VCI-F2 of
the received cell. Therefore, the IWU 478 has the 16 bits VCI field as
the table entry, and as a result, has the function to analyze the
VCI/VPI data. The VPI-F of the cell of the connection 6041 is analyzed
by the combination of VCI-F1 and VCI-F2. To the VCI-F1, VPI.sub.478-1
is
written, while the VCI-F2 is coded as the identifier of the **ATM**
connection between the ARS 482 to the ARS 481 by the analysis of the
VCI
field data. The value of the VCI-F2 is determined at a time of setting
the **ATM** connections (connections 6021, 6041, and 6061). The
assignment of the VCI-F2 can be made by the process for managing the
VCI-F2 within the sub-networks (networks 471 472, and 474), or by the
process for managing the value of the VCI-F2 at the terminals (ARS 481,
IWU 476, and ARS 484).

DETD   By the setting scheme of the VCI/VPI field as in the above, even when
the ARS has transmitted the data over a plurality of cells to the other
ARS, the re-assembling of the data at the receiving side can be done
without any problem. Here, for the data identification such as which
terminal has the data transmitted from or whether the data is related
to
the **address resolution** protocol, there is a need to
use the upper layer identification field.

DETD   FIG. 28 shows the setting of the **ATM** connections required for
transmitt⬤ the datagram from the termina⬤A to the terminal 47F,
the

public network 475, and the terminal 47D. Here, the datagram
transmission can be carried out in either one of the following two
schemes.

DETD   In this case, two **ATM** connections are required. One is formed
by the connections 621 and 624 between the terminal 47A and the CLSF
491, while the other is formed by the connection 625 between the CLSF
491 and the terminal 47F. The terminal 47A transmits to the IWU 476 the
cell with the VPI-F having VPI.sub.476-2 which is the access address of
the IWU 476 for the network 472, the VCI-F1 having the VPI.sub.47A
which

is the access address of the terminal 47A, and the VCI-F2 having a
value

set at a time of setting the connection 621. The IWU 476 analyzes the
VCI of the received cell, as well as the corresponding VPI-F and the
VCI-F2. Then, to the VCI-F1, VPI.sub.476-1 which is the access address
of the IWU 476 for the network 471 is written. Here, the VCI-F2 is a
value which is determined at a time of setting the connection 624,
which

can be written by copying the value of the VCI-F1 of the cell received
by the IWU 476, i.e., the VPI.sub.47A which is the access address of
the

terminal 47A.

DETD   The datagram arrived at the CLSF 491 is cell re-assembled once, and the
ATM connection is terminated. The CLSF 491 analyzes the upper
layer address data and recognizes that the destination of the datagram
as the terminal 47F. Then, the CLSF 491 generates the cell with the
VPI-F having VPI.sub.47F which is the access address of the terminal
47F, the VCI-F1 having the VPI.sub.491 which is the access address of
the CLSF 491, and the VCI-F2 having an identification number assigned
to

the connection 625, and transmits the datagram to the terminal 47F.
Here, the terminal 47F can uniquely identify the datagram to which the
cell belongs from the VCI-F1 and the VCI-F2. Namely, the datagram can
be

re-assembled at the terminal 47F.

DETD   In this case, only one **ATM** connection formed by the
connections 622, 626, and 627 between the terminal 47A and the public
network 475 is required. The terminal 47A transmits to the IWU 476 the
cell with the VPI-F having VPI.sub.476-2 which is the access address of
the IWU 476 for the network 472, the VCI-F1 having the VPI.sub.47A
which

is the access address of the terminal 47A, and the VCI-F2 having a
value

set at a time of setting the connection 622. The IWU 476 analyzes the
VCI of the received cell, as well as the corresponding VPI-F and the
VCI-F2. Then, to the VCI-F1, VPI.sub.476-1 which is the access address
of the IWU 476 for the network 471 is written. Here, the VCI-F2 is a
value which is determined at a time of setting the connection 626,
which

can be written by copying the value of the VCI-F1 of the cell received
by the IWU 476, i.e., the VPI.sub.47A which is the access address of
the

terminal 47A. The IWU 479 writes the VCI/VPI assigned to the **ATM**
connection 627 defined by the public network 475 according to the VCI
data of the received cell, and transmits the cell to the public network
475.

DETD   In this case, two **ATM** connections are required. One is formed
by the connections 623, 628, and 629 between the terminal 47A and the
CLSF 494, while the other is formed by the connection 62A between the
CLSF 494 and the terminal 47D. The terminal 47A transmits to the IWU
476

the cell with the VPI-F having VPI.sub.476-2 which is the access
address

of the IWU 476 for the network 472, the VCI-F1 having the VPI.sub.47A
which is ● access address of the terminal ●A, and the VCI-F2 having

a

value set at a time of setting the connection 623. The IWU 476 analyzes
the VCI of the received cell, as well as the corresponding VPI-F and

the

VCI-F2. Then, to the VCI-F1, VPI.sub.476-1 which is the access address
of the IWU 476 for the network 471 is written. Here, the VCI-F2 is a
value which is determined at a time of setting the connection 628,

which

can be written by copying the value of the VCI-F1 of the cell received
by the IWU 476, i.e., the VPI.sub.47A which is the access address of

the

terminal 47A.

DETD   The datagram arrived at the CLSF 494 is cell re-assembled once, and the
    ATM connection is terminated. The CLSF 494 analyzes the upper
layer address data and recognizes that the destination of the datagram
as the terminal 47D. Then, the CLSF 494 generates the cell with the
VPI-F having VPI.sub.47D which is the access address of the terminal
47D, the VCI-F1 having the VPI.sub.494 which is the access address of
the CLSF 494, and the VCI-F2 having an identification number assigned

to

the connection 62A, and transmits the datagram to the terminal 47D.
Here, the terminal 47D can uniquely identify the datagram to which the
cell belongs from the VCI-F1 and the VCI-F2. Namely, the datagram can

be

re-assembled at the terminal 47D.

DETD   In this scheme, each CLSF has obtained the VPI address, and all the
connections identified by the obtained VPIs are **ATM**
connections to be used for the cell transmission related to the

datagram

transmission (connection-less communication). Namely, the CLSF
    server requires the **ATM** connection (not
connection-less one) in order for itself to carry out the communication
with the other terminal/**server**. In other words, there is a
need for the CLSF to obtain at least two access addresses (VPIs) at a
time of the boot.

DETD   By the scheme as in the above, in the procedure for the **address**
    resolution which precedes the datagram transmission, the
terminal can transmits the datagram (one or more cells) as long as the
identification number of the sub-network to which the destination
terminal belongs. This datagram transmission will now be described in
detail.

DETD   The datagram arrived at the CLSF 491 is cell re-assembled once, and the
    ATM connection is terminated. The CLSF 491 analyzes the upper
layer address data and recognizes that the destination of the datagram
as the terminal 47F. Then, the CLSF 491 generates the cell with the
VPI-F having VPI.sub.47F which is the access address of the terminal
47F, and transmits the datagram to the terminal 47F. Here, the CLSF 491
can uniquely identify the datagram to which the cell belongs from the
VCI-F1 and the VCI-F2. Namely, the datagram can be re-assembled at the
CLSF 491. Therefore, it is also possible to carry out the pipeline type
relaying of the datagram (cell).

DETD   The IWU 476 analyzes the VCI of the received cell, as well as the
corresponding VPI-F and the VCI-F2. For example, in a case the VCI-F1
has the VPI.sub.479 which is the access address of the IWU 479, the
VPI-F of the cell to be outputted can be obtained by copying the VCI-F1
of the received cell. Then, to the VCI-F1, VPI.sub.476-1 which is the
access address of the IWU 476 for the network 471 is written. Here, the
VCI-F2 can be set to be transparent. Namely, in a case the VCI-F1 of

the

cell to be transmitted from the terminal 47A has VPI.sub.479, the
relaying of the cell can be realized by the procedure of (1) copying

the

VCI-F1 of the received cell to the VPI-F of the transmission cell, (2)

DETD copying the VCI-F2 of the received cell to the VCI-F2 of the
transmission cell, and (3) writing VPI.sub.5-1 to the VCI-F1 of the
transmission cell. The IWU 479 writes the VCI/VPI assigned to the
ATM connection 627 defined by the public network 475 according
to the VCI data of the received cell, and transmits the cell to the
public network 475.

DETD The datagram arrived at the CLSF 494 is cell re-assembled once, and the
ATM connection is terminated. The CLSF 494 analyzes the upper
layer address data and recognizes that the destination of the datagram
as the terminal 47D. Then, the CLSF 494 generates the cell with the
VPI-F having VPI.sub.47D which is the access address of the terminal
47D, and transmits the datagram to the terminal 47D. Here, the terminal
47D can uniquely identify the datagram to which the cell belongs from
the VCI-F1 and the VCI-F2. Namely, the datagram can be re-assembled at
the terminal 47D. More specifically, for example, the sub-network to
which the transmission source terminal belongs can be determined from
the VCI-F1, and the IWU which contains that sub-network can be
determined from the VCI-F2 as the identification number of that
sub-network.

DETD 3. General ATM network: Scheme II

DETD In this case, an exemplary hierarchical network architecture is as
shown
in FIG. 27 which comprises networks 631 to 635 with the
inter-networking
provided by the IWUs 636 to 639, including a public network 635
connected with the network 631 through an IWU 639. Here, each of the
IWUs 636 to 639 can realize the relaying of the ATM cells
without terminating the ATM connection, by having a function
to convert the VCI/VPI of the received cell into VCI/VPI assigned to
the
corresponding ATM connection in the neighboring network.

DETD FIGS. 28 and 29 show the two settings of the ATM connections
related to the address resolution, where the ARS 63G
is connected with the ARSs 63D, 63E, and 63F through the ATM
connections.

DETD FIG. 30 shows the setting of the ATM connections 641 to 646
required for transmitting the datagrams from the terminal 63A to the
terminal 63C, the public network 635, and the terminal 63B, where the
ATM connections 642, 644, and 645 are single direction
ATM connections from the CLSF-O 63M to the CLSF-I G3L, the
public network 635, and the CLSF-I 63J, respectively. Although not
shown
in FIG. 30, the similar ATM connections from each of the other
sub-networks are also provided. In addition, the ATM
connections among the CLSF-I and the CLSF-O as shown in FIG. 31 are
also
provided.

DETD Here, in a case of the connection-less communication from the public
network 635 to the terminal belonging to the defined networks 631 to
634, the ATM connection related to the connection-less
communication from the public network 635 is terminated at a
server for terminating this ATM connection for the
connection-less communication and relaying the datagram, which is
provided in the network 631. The datagram is transmitted from this
server to the destination terminal by the same procedure as
described below for the datagram transmission from the terminal within
the network to the terminal within the other network.

DETD Now, in this case, the protocol at the terminal is as follows. Namely,
when the terminal judges that the datagram is destined to the external
sub-network, the terminal transmits the datagram to the CLSF-O. Here,
the ATM connection is assumed to be already set up between the
terminal and the CLSF-O. Each terminal has the address space data (such
as address masks) for the sub-network to which it belongs, so that it
is
possible for each terminal to judge whether the destination terminal is

the terminal within its own network or the terminal of the external
sub-network

DETD (1) In this scheme, the CLSF-O and the CLSF-I are located at the same
access point, and the star-shaped **ATM** connections are set up
from between the CLSF and the terminals. The terminal transmits the
cell
to the CLSF whenever the datagram transmission is to be carried out.
The
datagram delivery is entirely carried out by the CLSF. Namely, even the
communication between the terminals within the same sub-network is
realized via the CLSF.

DETD In this case, the star-shaped **ATM** connections (bidirectional
communication channels) are formed from the ARS 63G in the network 631
to the ARSs 63D, 63E, and 63F in the networks 632 to 634, respectively,
as shown in FIG. 28. For example, in order to utilize the **ATM**
connection set up between the CLSF-O 63M and the CLSF-I 63J so as to
transmit the datagram from the terminal 63A to the terminal 63B, there
is a need for the CLSF-O 63M to obtain the VCI/VPI data of this
ATM connection. In order to obtain this VCI/VPI, the CLSF-O 63M
transmits the AR request cell having the address data of the terminal
47B to the ARS 63D of its own network 632 which is the address data
written in the received datagram. The ARS 63D which received this AR
request cell then analyzes the address of the destination terminal
written in the received cell, and when It Is impossible to carry out
the
address resolution from the data possessed by it, the
ARS 63D relays the AR request cell to the ARS 63G in the network 631
through the already set up **ATM** connection 651.

DETD Here, the **address resolution** at the ARS 63G is
carried out as follows. Namely, the ARS 63G has the address data
(address space data) of the terminals contained in its own network 631
and the address space data for the sub-networks 632 to 634. Then, the
ARS 63G analyzes the transmission target network by comparing the
address written in the received AR request cell with the address space
data for each sub-network.

DETD In this manner, the ARS 63G possesses the addresses and the address
space data of the terminals belonging to the network 631 and the
sub-networks 632, 633, and 634, so as to carry out the **address
resolution**. Here, it is not necessary for the ARS 63G to possess
the address data up to the terminal level for the sub-network other
than
its own sub-network, and it suffices to possess the address data only
up
to the network address level.

DETD The address data (**ATM** layer address data) received by the ARS
63D from the ARS 63G is the data indicating the identifier (normally
VCI/VPI, but may contain the identification data for the upper layer)
of
the **ATM** connection to the CLSF-I in the target sub-network
from the IWU 636. For example, at a time of the datagram transmission
from the terminal 63A to the terminal 63B, the identifier of the
ATM connection 645 for making an access to the CLSF-I 63J is
notified as the AR response, whereas at a time of the datagram
transmission from the terminal 63A to the terminal 63C, the identifier
of the **ATM** connection 642 for making an access to the CLSF-I
63L is notified as the AR response.

DETD Here, the ARS 63D notifies the VCI/VPI data for correctly relaying the
ATM connection at the IWU 636 to the CLSF-O 63M, according to
the VCI/VPI data received from the ARS 463G. The VCI/VPI data notified
to the CLSF-O 63M is then rewritten into the other VCI/VPI at the IWU
636.

DETD In this case, the star-shaped **ATM** connections as shown in FIG.
28 described above is formed from the ARS 63G in the network 631 to the
ARSs 632 to 634 in the networks 632 to 634, respectively, or the meshed
ATM connections as shown in FIG. 29 is formed by the ARSs 63D to

63G. Each ARS obtains the address space data and the **ATM** connection data (VCI/VPI) for the external sub-networks viewed from its own sub-network using the **ATM** connections defined as shown in FIG. 28 or FIG. 29. Here, FIG. 28 is in a form in which the ARS 63G functions as a master ARS, while FIG. 29 is in a distributed form in which each ARS operates independently. In a case the number of hierarchical levels in the network is at most three, a case of FIG. 28 to make the backbone network as the master is more appropriate.

DETD   Here, the **address resolution** at the ARS 63D is carried out as follows. Namely, the ARS 63D has the address data (address space data) of the terminals contained in its own network 632 and the address space data for the sub-networks 631, 633, and 634.

Then,   the ARS 63D analyzes the transmission target network by comparing the address written in the received AR request cell with the address space data for each sub-network.

DETD   In this manner, the ARS 63D possesses the addresses and the address space data of the terminals belonging to the network 632 and the sub-networks 631, 633, and 634, so as to carry out the **address resolution**. Here, it is not necessary for the ARS 63D to possess the address data up to the terminal level for the sub-network other than its own sub-network, and it suffices to possess the address data only up to the network address level.

DETD   The address data (**ATM** layer) received by the ARS 63D from the other ARS is the data indicating the identifier (normally VCI/VPI, but may contain the identification data for the upper layer) of the **ATM** connection to the CLSF-I in the target sub-network from the IWU 636. For example, at a time of the datagram transmission from the terminal 63A to the terminal 63B, the identifier of the **ATM** connection 645 for making an access to the CLSF-I 63J is notified as the AR response, whereas at a time of the datagram transmission from the terminal 63A to the terminal 63C, the identifier of the **ATM** connection 642 for making an access to the CLSF-I 63L is notified as the AR response. Here, the ARS 63D notifies the VCI/VPI data for correctly relaying the **ATM** connection at the IWU 636 to the CLSF-O 63M, according to the VCI/VPI data received from the other ARS. The VCI/VPI data notified to the CLSF-O 63M is then rewritten into the other VCI/VPI at the IWU 636.

DETD   Among ARSs, not only the address space data exchange protocol for each sub-network, but also the routing protocol concerning the datagram transmission (connection-less communication) among the sub-networks is also operated. More specifically, this routing protocol carries out the management of the **ATM** connection setting as shown in FIG. 30 described above. Here, the individual **ATM** connection is separated at the IWU (i.e., closed within the sub-network), and the **ATM** connection routing control and the **ATM** connection management (such as VCI/VPI management) are made by the other **ATM** connection **server** process and the routing **server** process, and the ARS exchanges the control messages with these **servers** as well as the IWU to carry out the management of the **ATM** connections necessary for the connection-less communication.

DETD   Thus, it suffices for each CLSF to possess only the address data of the terminals of the network to which that CLSF itself belongs. When the address of the of the received datagram is present in its own network, the appropriate **ATM** connection is selected and the relaying of the datagram is carried out.

DETD   An exemplary protocol processing in a case of transmitting the datagram from the terminal 63A to the terminal 63B is shown in FIG. 32. Namely, the **ATM** connection is terminated at the CLSF-O 63M and the

CLSF-I 63J, i.e., the protocol of the OSI layer 3 is terminated at the CLSF-O 63M and the CLSF-I 63J. In this manner, at a time of the datagram
transmission to the terminal other than those of its own sub-network, the end-to-end datagram delivery can be realized with only two **ATM** connection termination.

DETD In this case, the **address resolution** is carried out as follows.

DETD In transmitting the datagram from the terminal 63A to the terminal 63B, when the terminal 63A recognizes that the terminal 63B belongs to the external sub-network, the terminal 63A transmits the datagram to the CLSF-O 63M. The CLSF-O 63M then analyzes the address data of the received datagram, and transmits the AR request cell having the address data of the terminal 63B to the ARS 63D when the CLSF-O 63M does not have the **ATM** layer address data for transmitting the datagram to the terminal 63B (or to the CLSF-I 63J).

DETD When the ARS 63D possesses the data enabling the **address resolution**, the AR request containing the VCI/VPI for transmitting the cell from the CLSF-O 63M to the CLSF-I 63J is directly transmitted. On the other hand, when the **address resolution** cannot be made at the ARS 63D, the appropriate ARS is accessed to carry out the **address resolution**. When the **address resolution** is completed, the resulting AR response is transmitted to the CLSF-O 63M.

DETD The terminal 63A transmits the cell having the datagram information to the CLSF-O 63M through the **ATM** connection 641. The CLSF-O 63M then analyzes the address data of the datagram, cell assembles the datagram, and transmits the cell to the CLSF-I 63J by using the **ATM** connection 645. The IWUs 636 and 637 carries out the relaying of the **ATM** connection by rewriting the VCI/VPI data of the received cell.

DETD At the CLSF-I 63J which is the terminal point of the **ATM** connection 645, the network layer processing is carried out. The CLSF-I 63J carries out the analysis of the network address, and the datagram is
relayed to the **ATM** connection 646 and transmitted to the terminal 63B.

DETD In this manner, there are only three **ATM** connections from the terminal 63A to the CLSF-O 63M, from CLSF-O 63M to the CLSF-I 63J, and from the CLSF-I 63J to the terminal 63B, so that they are terminated only twice.

DETD In this case, the manner of realizing the **ATM** connections set up among the ARSs is equivalent to that described above as 3. General **ATM** network: Scheme II, so that it will not be repeated here.

DETD With reference to FIG. 30 described above and FIG. 33, four available schemes for the setting of the **ATM** connections required for transmitting the datagram from the terminal 63A to the terminal 63C, the
public network 635, and the terminal 63B will be described.

DETD In this case, three **ATM** connections are required. One is formed by the connection 691 between the terminal 63A and the CLSF-O 63M, another is formed by the connections 692 and 693 between the CLSF-O
63M and the CLSF-I 63L, and still another is the connection 694 between the CLSF-I 63L and the terminal 63C. The terminal 63A transmits to the IWU 636 the cell with the VPI-F having VPI.sub.63M which is the access address of the CLSF-O 63M, and the VCI-F1 having VPI.sub.63A which is the access address of the terminal 63A. Then, the CLSF-O 63M transmits to the IWU 636 the cell with the VPI-F having VPI.sub.636-2 which is the
access address of the IWU 636 for the network 632, the VCI-F1 having the
VPI.sub.63M which is the access address of the CLSF-O 63M, and the VCI-F2 having a value set at a time of setting the connection 692. The IWU 636 analyzes the VCI of the received cell, as well as the

corresponding VPI-F and the VCI-F2. Then, to the VCI-F1, VPI.sub.636-1 which is ⬤ access address of the IWU 636⬤ the network 631 is written. Here, the VCI-F2 is a value which is determined at a time of setting the connection 693, which can be written by copying the value

of

the VCI-F1 of the cell received by the IWU 636, i.e., the VPI.sub.63M which is the access address of the CLSF-O 63M.

DETD The datagram arrived at the CLSF-I 63L is cell re-assembled once, and the ATM connection is terminated. The CLSF-I 63L analyzes the upper layer address data and recognizes that the destination of the datagram as the terminal 63C. Then, the CLSF-I 63L generates the cell with the VPI-F having VPI.sub.63C which is the access address of the terminal 63C, the VCI-F1 having the VPI.sub.63L which is the access address of the CLSF-I 63L, and the VCI-F2 having an identification number assigned to the connection 694, and transmits the datagram to

the

terminal 63C. Here, the terminal 63C can uniquely identify the datagram to which the cell belongs from the VCI-F1 and the VCI-F2. Namely, the datagram can be re-assembled at the terminal 63C.

DETD In this case, two ATM connections is required. One is formed by the connection 691 between the terminal 63A and the CLSF-O 63M,

while

the other is formed by the connections 692, 695, and 696 between the terminal CLSF-O 63M and the public network 635. The terminal 63A transmits the cell with the VPI-F having VPI.sub.63M which is the

access

address of the CLSF-O 63M. Then, the CLSF-O 63M transmits to the IWU

636

the cell with the VPI-F having VPI.sub.836-2 which is the access

address

of the IWU 636 for the network 632, the VCI-F1 having the VPI.sub.63M which is the access address of the CLSF-O 63M, and the VCI-F2 having a value set at a time of setting the connection 692. The IWU 638 analyzes the VCI of the received cell, as well as the corresponding VPI-F and

the

VCI-F2. Then, to the VCI-F1, VPI.sub.636-1 which is the access address of the IWU 636 for the network 631 is written. Here, the VCI-F2 is a value which is determined at a time of setting the connection 695,

which

can be written by copying the value of the VCI-F1 of the cell received by the IWU 636, i.e., the VPI.sub.63M which is the access address of

the

CLSF-O 63M. The IWU 639 writes the VCI/VPI assigned to the ATM connection 696 defined by the public network 635 according to the VCI data of the received cell, and transmits the cell to the public network 635.

DETD In this case, three ATM connections are required. One is formed by the connection 691 between the terminal 63A and the CLSF-O 63M, another is formed by the connections 692, 697, and 698 between the CLSF-O 63M and the CLSF-I 63J, and still another is formed by the connection 699 between the CLSF-I 63J and the terminal 63B. The

terminal

63A transmits the cell with the VPI-F having VPI.sub.63M which is the access address of the CLSF-O 63M. Then, the CLSF-O 63M transmits to the IWU 636 the cell with the VPI-F having VPI.sub.636-2 which is the

access

address of the IWU 636 for the network 632, the VCI-F1 having the VPI.sub.63M which is the access address of the CLSF-O 63M, and the VCI-F2 having a value set at a time of setting the connection 692. The IWU 636 analyzes the VCI of the received cell, as well as the corresponding VPI-F and the VCI-F2. Then, to the VCI-F1, VPI.sub.636-1 which is the access address of the IWU 636 for the network 631 is written. Here, the VCI-F2 is a value which is determined at a time of setting the connection 697, which can be written by copying the value

of

the VCI-F1 of the cell received by the IWU 636, i.e., the VPI.sub.63M
which is ⬤ access address of the CLSF-O ⬤.

DETD   The datagram arrived at the CLSF-I 63J is cell re-assembled once, and
the **ATM** connection is terminated. The CLSF-I 63J analyzes the
upper layer address data and recognizes that the destination of the
datagram as the terminal 63B. Then, the CLSF-I 63J generates the cell
with the VPI-F having VPI.sub.63B which is the access address of the
terminal.sub.63B, the VCI-F1 having the VPI.sub.63J which is the access
address of the CLSF-I 63J, and the VCI-F2 having an identification
number assigned to the connection 699, and transmits the datagram to
the
terminal 63B. Here, the terminal 63B can uniquely identify the datagram
to which the cell belongs from the VCI-F1 and the VCI-F2. Namely, the
datagram can be re-assembled at the terminal 63A.

DETD   In this scheme, each CLSF-O carries out the re-assembling of the
datagram, but the **address resolution** is carried out
by each terminal. The address data of the target network obtained by
the
address resolution is written in the VCI-F1 of the
cell transmitted from the terminal to the CLSF-O. Here, the cell
transmission (datagram transmission) from the CLSF-O cannot be carried
out in the pipeline-like manner, but there is no need for the CLSF-O to
carry out the **address resolution** of the network to
which the destination terminal belongs according to the address data in
the received datagram.

DETD   In this scheme, each IWU, CLSF-O and CLSF-I has obtained the VPI
address, and all the connections identified by the obtained VPIs are
ATM connections to be used for the cell transmission related to
the datagram transmission (connection-less communication). Namely, each
of the CLSF **server** and the IWU requires the **ATM**
connection (not connection-less one) in order for itself to carry out
the communication with the other terminal/**server**. In other
words, there is a need for the CLSF to obtain at least two access
addresses (VPIs) at a time of the boot.

DETD   By the scheme as in the above, in the procedure for the **address
resolution** which precedes the datagram transmission, the
terminal can transmits the datagram (one or more cells) as long as the
identification number of the sub-network to which the destination
terminal belongs. This datagram transmission will now be described in
detail.

DETD   The datagram arrived at the CLSF-I 63L is cell re-assembled once, and
the **ATM** connection is terminated. The CLSF-I 63L analyzes the
upper layer address data and recognizes that the destination of the
datagram as the terminal 63C. Then, the CLSF-I 63L generates the cell
with the VPI-F having VPI.sub.63C which is the access address of the
terminal 63C, and transmits the datagram to the terminal 63C. Here, the
terminal 63C can uniquely identify the datagram to which the cell
belongs from the VCI-F1 and the VCI-F2. Namely, the datagram can be
re-assembled at the terminal 63C.

DETD   The IWU 639 writes the VCI/VPI assigned to the **ATM** connection
696 defined by the public network 635 according to the VCI data of the
received cell, and transmits the cell to the public network 635.

DETD   The datagram arrived at the CLSF-I 63J is cell re-assembled once, and
the **ATM** connection is terminated. The CLSF-I 63J analyzes the
upper layer address data and recognizes that the destination of the
datagram as the terminal 63B. Then, the CLSF-I 63J generates the cell
with the VPI-F having VPI.sub.63B which is the access address of the
terminal 63D, and transmits the datagram to the terminal 63D. Here, the
terminal 63B can uniquely identify the datagram to which the cell
belongs from the VCI-F1 and the VCI-F2. Namely, the datagram can be
re-assembled at the terminal 63B.

DETD   In this scheme, each CLSF-O carries out the re-assembling of the
datagram, but the **address resolution** is carried out
by each terminal, so that there is no need for the CLSF-O to carry out
the **address resolution** of the network to which the

destination terminal belongs according to the address data within the received diagram. The address data of the target network obtained by the **address resolution** is written in the VCI-F1 of the cell transmitted from the terminal to the CLSF-0.

DETD   The datagram arrived at the CLSF-I 63L is cell re-assembled once, and the **ATM** connection is terminated. The CLSF-I 63L analyzes the upper layer address data and recognizes that the destination of the datagram as the terminal 63C. Then, the CLSF-I 63L generates the cell with the VPI-F having VPI.sub.63C which is the access address of the terminal 63C, and transmits the datagram to the terminal 63C. Here, the terminal 63C can uniquely identify the datagram to which the cell belongs from the VCI-F1 and the VCI-F2. Namely, the datagram can be re-assembled at the terminal 63C.

DETD   The IWU 639 writes the VCI/VPI assigned to the **ATM** connection 696 defined by the public network 635 according to the VCI data of the received cell, and transmits the cell to the public network 635.

DETD   The datagram arrived at the CLSF-I 63J is cell re-assembled once, and the **ATM** connection is terminated. The CLSF-I 63J analyzes the upper layer address data and recognizes that the destination of the datagram as the terminal 63B. Then, the CLSF-I 63J generates the cell with the VPI-F having VPI.sub.63B which is the access address of the terminal 63D, and transmits the datagram to the terminal 63D. Here, the terminal 63B can uniquely identify the datagram to which the cell belongs from the VCI-F1 and the VCI-F2. Namely, the datagram can be re-assembled at the terminal 63B.

DETD   In this scheme, each CLSF-0 carries out the reassembling of the datagram, but the **address resolution** is carried out by each terminal, so that there is no need for the CLSF-0 to carry out the **address resolution** of the network to which the destination terminal belongs according to the address data within the received datagram. The address data of the target network obtained by the **address resolution** is written in the VCI-F1 of the cell transmitted from the terminal to the CLSF-0.

DETD   Step 4: The end of the datagram transmission can be recognized by the CLSF-0 according to the identification codes above the **ATM** layer such as those of the payload type coding in the AAL 5 for example.
In a case there is no other datagram transmission with respect to the analyzed target sub-network, the received cell is relayed to the target sub-network. Here, the received cell is transmitted in the pipeline-like manner, i.e., without being re-assembled once at the CLSF-0.

DETD   The datagram arrived at the CLSF-I 63L is cell re-assembled once, and the **ATM** connection is terminated. The CLSF-I 63L analyzes the upper layer address data and recognizes that the destination of the datagram as the terminal 63C. Then, the CLSF-I 63L generates the cell with the VPI-F having VPI.sub.63C which is the access address of the terminal 63C, and transmits the datagram to the terminal 63C. Here, the terminal 63C can uniquely identify the datagram to which the cell belongs from the VCI-F1 and the VCI-F2. Namely, the datagram can be re-assembled at the terminal 63C.

DETD   The IWU 639 writes the VCI/VPI assigned to the **ATM** connection 696 defined by the public network 635 according to the VCI data of the received cell, and transmits the cell to the public network 635.

DETD   The datagram arrived at the CLSF-I 63J is cell re-assembled once, and the **ATM** connection is terminated. The CLSF-I 63J analyzes the upper layer address data and recognizes that the destination of the datagram as the terminal 63B. Then, the CLSF-I 63J generates the cell with the VPI-F having VPI.sub.63B which is the access address of the terminal 63D, and transmits the datagram to the terminal 63D. Here, the terminal 63B can uniquely identify the datagram to which the cell belongs from the VCI-F1 and the VCI-F2. Namely, the datagram can be re-assembled at the terminal 63B.

DETD   FIG. 34 shows a system configuration of the network with the falt topology, in which a plurality of sub-networks 701 to 706 with the

inter-networking provided by the IWUs 70D, 70E, 70F, 70G, 70H, and 70J. In addition the public networks 707 and 708 are connected with the networks 703 and 704 through the IWUs 70K and 70M, respectively. Here, each IWU can realize the relaying of the **ATM** cells without terminating the **ATM** connection, by having a function to convert the VCI/VPI of the received cell into VCI/VPI assigned to the corresponding **ATM** connection in the neighboring network.

DETD   Also, in this case, the manner of realizing the **address resolution** is basically equivalent to that in the hierarchical network described above, so that the description concerning the manner of constructing the **ATM** connections related to the **address resolution** will not be repeated here. Namely, there are two schemes including a scheme in which all the **address resolution servers** are equal and analyze the address data of the network independently, and a scheme in which the address data are managed and analyzed by the logical hierarchical structure among the **address resolution servers**. As for the **ATM** connections to be set up among the **address resolution servers**, they can have any desired structure ranging from the full meshed structure to the minimally spanning tree structure.

DETD   1. General **ATM** Network: Scheme I

DETD   In this case, the **ATM** connections are provided as follows. Namely, in order to transmit the datagram from the terminal connected to each sub-network to the terminal connected to an optional sub-network, the **ATM** connections are set up from each IWU to the CLSFs provided within all the sub-networks. That is, the single direction **ATM** connections from the IWU to the CLSFs are set up in the fully meshed manner. Here, the IWU (relaying IWU) provided on the route of the **ATM** connection carries out the rewriting of the **ATM** header data or at least the VCI/VPI conversion, and the cell relaying is executed as the work at the **ATM** layer. In other words, the **ATM** connection is not terminated in principle at the IWU. Also, it is also possible for the CLSF to be provided at a position of the IWU if desired.

DETD   Here, when the datagram is transmitted to the network defined by the public networks 707 and 708, the received cell to which the datagram belongs is transmitted to the **server** for terminating the datagram connection of the public network once. This **server** can also be provided on the IWU if desired. The **server** which terminated the datagram transmitted from the public network relays the datagram by the same procedure as the datagram transmission from the terminal within the defined network.

DETD   The exemplary **ATM** connection configuration at a time of transmitting the datagram from the public network 707 to the terminal 70A is shown in FIG. 35. In this exemplary case, the datagram transmitted from the public network 707 is terminated at the CLSF-P 811 once, and then transmitted to the terminal 70A via the CLSF 7011. Therefore, there are three **ATM** connections 812, 813, and 814.

DETD   (1) The terminal makes the AR request. This can be done either always or only in a case the **address resolution** cannot be made by the terminal itself such as a case in which a suitable entry is present in the AR table.

DETD   (2) The terminal obtains the VCI/VPI data which is the identifier of the **ATM** connection provided from the ARS in order to make an access to the destination terminal.

DETD   Here, at a time of the datagram transmission, there is no need for the terminal to carry out the procedure for setting up a particular connection defined in the **ATM** network.

DETD   Thus, it suffices for each CLSF to possess only the address data of the terminals of the network to which that CLSF itself belongs. When the

address of the of the received datagram is present in its own network, the appropriate **ATM** connection is selected and the relaying of the datagram is carried out.

DETD An exemplary protocol processing in a case of transmitting the datagram from the public network 707 to the terminal 70A through the **ATM** connections of FIG. 35 described above is shown in FIG. 36. Similarly, an exemplary protocol processing in a case of transmitting the datagram from the terminal 70A to the terminal 70B through the **ATM** connections of FIG. 37 is shown in FIG. 38 for the datagram relayed through paths 771 to 776 shown in FIG. 39. In this case, the **ATM** connection is terminated at the CLSF 7061 once, i.e., the protocol of the OSI layer 3 is terminated at the CLSF 7061. The OSI layer 3 protocol

processing is carried out at the CLSF 7061, and the data unit is transmitted to the terminal 70B using the **ATM** connection. In this manner, at a time of the datagram transmission to the terminal other than those of its own sub-network, the end-to-end datagram delivery can be realized with only one **ATM** connection termination.

DETD Similarly, an exemplary protocol processing in a case of transmitting the datagram from the terminal 70A to the public network 708 through the

ATM connections of FIG. 40 is shown in FIG. 41 for the datagram relayed through paths 781 to 783 shown in FIG. 42.

DETD In transmitting the datagram from the terminal 70A to the terminal 70B, the required **ATM** connection configuration is as shown in FIG. 37. Here, at a time of the datagram transmission, the terminal 70A carries out the **address resolution** of the terminal 70B by analyzing the access address data of the sub-network to which the

terminal 70B belongs. Namely, the terminal 70A transmits the AR request message containing the address data of the terminal 70B to the ARS. The ARS which received this AR request then carries out the **address resolution** and returns to the terminal 70A the AR response indicating the VCI/VPI data for transmitting the cell to the terminal 70B.

DETD The terminal 70A which obtained the **ATM** layer address (VCI/VPI) data for transmitting the cell to the terminal 70B then outputs the cell attached with the VCI/VPI to the network. Then, after the VCI/VPI conversion at the IWU 70D, the cell is transmitted to the IWU 70G. Similarly, the cell is transmitted to the CLSF 7061 via the IWUs 70H and 70J. The CLSF 7061 which received this cell then analyzes the layer 3 address data of the datagram and transmits the cell to the terminal 70B. Here, the cell transmission from the CLSF 7061 to the terminal 70B may be made after all the cells belonging to the datagram are received by the CLSF 7061, or by the pipeline-like cell relaying after the analysis of the layer 3 address data of the datagram.

DETD In transmitting the datagram from the terminal 70A to the public network 708, the required **ATM** connection configuration is as shown in FIG. 40. Here, at a time of the datagram transmission, the terminal 70A carries out the **address resolution** of the target terminal by analyzing the access address data of the sub-network to which the destination terminal belongs. Namely, the terminal 70A transmits the AR request message containing the address data of the destination terminal to the ARS. The ARS which received this AR request then carries out the **address resolution** and returns to the terminal 70A the AR response indicating the VCI/VPI data for transmitting the cell to the destination terminal.

DETD The terminal 70A which obtained the **ATM** layer address (VCI/VPI) data for transmitting the cell to the terminal 70B then outputs the cell attached with the VCI/VPI to the network. Then, after the VCI/VPI conversion at the IWU 70D, the cell is transmitted to the IWU 70E. Similarly, the cell is transmitted to the public network 708 via the IWU 70M.

DETD   In transmitting the datagram from the public network 707 to the terminal

70A, the required **ATM** connection configuration is as shown in FIG. 35. Here, the transmission source terminal Is present within the public network 707, and the cell related to the connection-less communication from the public network 707 is transmitted to the CLSF-P 811 via the IWU 70K. The VCI/VPI conversion table provided at the IWU 70K is set such that the cell is transmitted to the CLSF-P 811 whenever the cell having the VCI/VPI assigned to the cell used by the connection-less communication in the public network 707 has arrived.

DETD   The CLSF-P 811 terminates the **ATM** connection once, and analyzes the layer 3 address data of the datagram. In a case the address

data to be analyzed is not present in the table within the CLSF-P 811, the CLSF-P 811 transmits the AR request to the ARS. The CLSF-P 811 which

obtained the **ATM** layer address (VCI/VPI) data for transmitting the cell to the terminal 70A then outputs the cell attached with the VCI/VPI to the network. After the VCI/VPI conversion at the IWU 70G, the

cell is transmitted to the IWU 70D, and then to the CLSF 7011. The CLSF 7011 which received the cell then analyzes the layer 3 address data of the datagram, and transmits the cell to the terminal 70A. Here, the cell

transmission from the CLSF 7011 to the terminal 70A and the cell transmission from the CLSF-P 811 to the IWU 70G may be made after all the cells belonging to the datagram are received by the CLSF 7061 or the

CLSF-P 811, or by the pipeline-like cell relaying after the analysis of the layer 3 address data of the datagram.

DETD   2. General **ATM** Network: Scheme II

DETD   In this case, the **ATM** connections are provided as follows. Namely, in order to transmit the datagram from the terminal connected to

each sub-network to the terminal connected to an optional sub-network, the **ATM** connections are set up from each CLSF to the CLSFs provided within all the sub-networks. That is, the **ATM** connections among the CLSFs are set up in the fully meshed manner. Here,

the IWU (relaying IWU) provided on the route of the **ATM** connection carries out the rewriting of the **ATM** header data or at least the VCI/VPI conversion, and the cell relaying is executed as the work at the **ATM** layer. In other words, the **ATM** connection is not terminated in principle at the IWU. Also, it is also possible for the CLSF to be provided at a position of the IWU if desired.

DETD   Here, when the datagram is transmitted to the network defined by the public networks 707 and 708, the received cell to which the datagram belongs is transmitted to the **server** for terminating the datagram connection of the public network once. This **server** can also be provided on the IWU if desired. The **server** which terminated the datagram transmitted from the public network relays the datagram by the same procedure as the datagram transmission from the terminal within the defined network.

DETD   The exemplary **ATM** connection configuration at a time of transmitting the datagram from the public network 707 to the terminal 70A is shown in FIG. 43. In this exemplary case, the datagram transmitted from the public network 707 is terminated at the CLSF-P 811 once, and then transmitted to the terminal 70A via the CLSFs 7031 and 7011. Therefore, there are four **ATM** connections 831, 832, 833, and 834.

DETD   Now, in this case, the protocol at the terminal is as follows. Namely, when the terminal Judges that the datagram is destined to the external sub-network, the terminal transmits the datagram to the CLSF. This CLSF is usually present in the same sub-network as the terminal, but the CLSF

may be provided at the other sub-network such as that of the
neighboring
                    node if desired. Here, the **ATM** connection is assumed to be
                    already set up between the terminal and the CLSF. Each terminal has the
                    address space data (such as address masks) for the sub-network to which
                    it belongs, so that it is possible for each terminal to judge whether
                    the destination terminal is the terminal within its own network or the
                    terminal of the external sub-network.
DETD   An exemplary protocol processing in a case of transmitting the datagram
                    from the public network 707 to the terminal 70A through the **ATM**
                    connections of FIG. 43 described above is shown in FIG. 44.
DETD   (1) In this scheme, the star-shaped **ATM** connections are set up
                    from between the CLSF and the terminals. The terminal transmits the
cell
                    to the CLSF whenever the datagram transmission is to be carried out.
The
                    datagram delivery is entirely carried out by the CLSF. Namely, even the
                    communication between the terminals within the same sub-network is
                    realized via the CLSF.
DETD   Thus, it suffices for each CLSF to possess only the address data of the
                    terminals of the network to which that CLSF itself belongs. When the
                    address of the of the received datagram is present in its own network,
                    the appropriate **ATM** connection is selected and the relaying of
                    the datagram is carried out.
DETD   An exemplary **ATM** connection configuration in a case of
                    transmitting the datagram from the terminal 70A to the terminal 70B is
                    shown in FIG. 45 for the datagram relayed through the paths 791 to 797
                    shown in FIG. 46. Namely, the **ATM** connection is terminated at
                    the CLSFs 7061 and 7011. The OSI layer 3 protocol processing is carried
                    out at the CLSF 7011, and the data unit is transmitted to the IWU 70D
                    using the **ATM** connection. Also, the OSI layer 3 protocol
                    processing is carried out at the CLSF 7061, and the data unit is
                    transmitted to the terminal 70B using the **ATM** connection. In
                    this manner, at a time of the datagram transmission to the terminal
                    other than those of its own sub-network, the end-to-end datagram
                    delivery can be realized with only two **ATM** connection
                    terminations.
DETD   Similarly, an exemplary **ATM** connection configuration in a case
                    of transmitting the datagram from the terminal 70A to the public
network
                    708 is shown in FIG. 47 for the datagram relayed through the paths 801
                    to 804 shown in FIG. 48.
DETD   In transmitting the datagram from the terminal 70A to the terminal 70B,
                    the required **ATM** connection configuration is as shown in FIG.
                    45. Here, at a time of the datagram transmission, the terminal 70A
                    transmits the datagram to the CLSF 7011 when it is analyzed that the
                    terminal 70B is the terminal belonging to the external sub-network. The
                    CLSF 7011 then analyzes the address data of the received datagram, and
                    transmits the AR request cell having the address data of the terminal
                    70B to the ARS when it does not possess the **ATM** layer address
                    data for transmitting the datagram to the terminal 70B (CLSF 7061). The
                    ARS which received this AR request then carries out the **address
              resolution** and returns to the CLSF 7011 the AR response
                    indicating the VCI/VPI data for transmitting the cell to the CLSF 7061
                    (terminal 70B).
DETD   The CLSF 7011 which obtained the **ATM** layer address (VCI/VPI)
                    data for transmitting the cell to the terminal 70B then outputs the
cell
                    attached with the VCI/VPI to the network. Then, after the VCI/VPI
                    conversion at the IWU 70D, the cell is transmitted to the IWU 70G.
                    Similarly, the cell is transmitted to the CLSF 7061 via the IWUs 70H
and
                    70J. The CLSF 7061 which received this cell then analyzes the layer 3
                    address data of the datagram and transmits the cell to the terminal
70B.

Here, the cell transmission from the CLSF 7061 to the terminal 70B may be made a●r all the cells belonging to t●atagram are received by the CLSF ●1, or by the pipeline-like cell relaying after the analysis of the layer 3 address data of the datagram.

DETD   In transmitting the datagram from the terminal 70A to the public network
708, the required **ATM** connection configuration is as shown in FIG. 47. Here, at a time of the datagram transmission, the terminal 70A carries out the **address resolution** of the target
terminal by analyzing the access address data of the sub-network to which the destination terminal belongs. Namely, the terminal 70A transmits the AR request message containing the address data of the destination terminal to the ARS when the terminal 70A cannot carry out the resolution of the address data of the destination terminal. The ARS which received this AR request then carries out the **address resolution** and returns to the terminal 70A the access address
data of the CLSF 7011 with the AR response indicating the VCI/VPI data for transmitting the cell to the destination terminal. Then, when it is analyzed that the destination terminal is the terminal belonging to the external sub-network, the terminal 70A attaches the VCI/VPI data either received or obtained from the analysis, and transmits the cell to the CLSF 7011.

DETD   The CLSF 7011 then analyzes the address data of the received datagram, and transmits the AR request cell having the address data of the destination terminal to the ARS when it does not possess the **ATM** layer address data for transmitting the datagram to the destination terminal. The ARS which received this AR request then carries out the **address resolution** and returns to the CLSF 7011 the AR
response indicating the VCI/VPI data for transmitting the cell to the IWU 70M.

DETD   The CLSF 7011 which obtained the **ATM** layer address (VCI/VPI) data for transmitting the cell to the terminal 70B then outputs the cell
attached with the VCI/VPI to the network. Then, after the VCI/VPI conversion at the IWU 70D, the cell is transmitted to the IWU 70E. Similarly, the cell is transmitted to the public network 708 via the IWU
70M.

DETD   In transmitting the datagram from the public network 707 to the terminal
70A, the required **ATM** connection configuration is as shown in FIG. 43. Here, the transmission source terminal is present within the public network 707, and the cell related to the connection-less communication from the public network 707 is transmitted to the CLSF-P 811 via the IWU 70K. The VCI/VPI conversion table provided at the IWU 70K is set such that the cell is transmitted to the CLSF-P 811 whenever the cell having the VCI/VPI assigned to the cell used by the connection-less communication in the public network 707 has arrived.

DETD   The CLSF-P 811 terminates the **ATM** connection once, and analyzes the layer 3 address data of the datagram. In a case the address
data to be analyzed is not present in the table within the CLSF-P 811, the CLSF-P 811 transmits the AR request to the ARS. The CLSF-P 811 which
obtained the **ATM** layer address (VCI/VPI) data for transmitting the cell to the CLSF 7031 then outputs the cell attached with the VCI/VPI to the network. The CLSF 7013 then analyzes the address data of the receive datagram

DETD   The CLSF 7031 then analyzes the address data of the received datagram, and transmits the AR request cell having the address data of the terminal 70A to the ARS when it does not possess the **ATM** layer address data for transmitting the datagram to the terminal 70A (CLSF 7011). The ARS which received this AR request then carries out the **address resolution** and returns to the CLSF 7031 the AR
response indicating the VCI/VPI data for transmitting the cell to the

CLSF 7011 (terminal 70A).

DETD   The CLSF ●1 which obtained the **ATM** laye●dress (VCI/VPI)
data for ●nsmitting the cell to the termi●al 70A then outputs the
cell
attached with the VCI/VPI to the network.

DETD   First, the coding of the VCI/VPI field of the cell from the
transmission
source terminal to the CLSF can be done as follows. Namely, in this
case, the VPI-F is an access address of the CLSF, while the VCI-F2 is
defined as the access address of the transmission source terminal. As
for the VCI-F1, there are two cases of carrying out the **address
resolution** of the sub-network to which the destination terminal
belongs either at the transmission source terminal or at the CLSF.

DETD   (a) In a case of carrying out the **address resolution**
at the transmission source terminal, the identification number
Net.sub.destination of the destination sub-network obtained by the
transmission source terminal is written into the VCI-F1.

DETD   (b) In a case of carrying out the **address resolution**
at the CLSF, the VCI-F1 can be set as an arbitrary value.

DETD   Next, the coding of the VCI/VPI field of the cell from the CLSF to the
IWU can be done as follows. Namely, in this case, the VPI-F is an
access
address of the IWU, and the VCI-F1 is set to be the identification
number Net.sub.destination of the destination network, while the VCI-F2
is set to be the identification number Net.sub.source of the network of
the transmission source terminal. Here, again, for the setting of the
VCI-F1, there are two cases of carrying out the **address
resolution** of the sub-network to which the destination terminal
belongs either at the transmission source terminal or at the CLSF.

DETD   (a) In a case of carrying out the **address resolution**
at the transmission source terminal, the identification number
Net.sub.destination of the destination sub-network obtained by the
transmission source terminal is copied into the VCI-F1.

DETD   (b) In a case of carrying out the **address resolution**
at the CLSF, a value obtained by the **address
resolution** is written into the VCI-F1.

DETD   First, with references to FIGS. 45 and 46, the datagram transmission
from the terminal 70A to the terminal 70B will be described. In this
case, three **ATM** connections are required, one formed by the
connection 791 from the terminal 70A to the CLSF 7011, another formed
by
the connections 792 to 796 from the CLSF 7011 to the CLSF 7961, and
still another formed by the connection 797 from the CLSF 7061 to the
terminal 70B.

DETD   The terminal 70A transmits the cell with the VPI-F having VPI.sub.7011,
while the VCI-F2 has VPI.sub.70A which is the access address of the
terminal 70A itself. Also, when the terminal 70A carries out the
address resolution of the address data (Net.sub.706)
of the sub-network to which the destination terminal belongs by itself,
this value Net.sub.706 is written into the VCI-F1. On the other hand,
when the CLSF 7011 carries out the **address resolution**
, the VCI-F1 can be set to an arbitrary value.

DETD   The IWU 70J recognizes that the cell has reached the target network
according to the VCI-F1 data, and transmits the cell to the CLSF 7061.
The datagram arrived to the CLSF 7061 is cell re-assembled once, and
the
ATM connection is terminated. The CLSF 7061 analyzes the address
data of the upper layer and recognizes that the destination of the
datagram as the terminal 70B. Then, the CLSF 7061 generates the cell
and
transmits the datagram to the terminal 70B. Here, the cell transmission
to the terminal 70B can be done in the pipeline-like manner since the
cell reception at the CLSf 7061 when there are sufficient amount of the
connection-less communication channels to the terminal 70B

DETD   Next, with reference to FIG. 47, the datagram transmission from the

terminal 70A to the public network 708 is described. The terminal 70A transmits ●e cell with VPI-F having VPI.s●7011, while the VCI-F2 has VPI.sub.7●which is the access address of ●e terminal 70A itself. Also, when the terminal 70A carries out the **address resolution** of the address data (Net.sub.708) of the sub-network to which the destination terminal belongs by itself, this value Net.sub.708 is written into the VCI-F1. On the other hand, when the

CLSF
7011 carries out the **address resolution**, the VCI-F1 can be set to an arbitrary value.

DETD The IWU 70M writes the VCI/VPI assigned to the **ATM** connection defined by the public network 708 from the VCI data of the received cell, and transmits the cell to the public network.

DETD In this case, four **ATM** connections 881 to 884 as shown in FIG. 52 are required, including an **ATM** connection 881 from the terminal 87A of the network 881 to a CLSF 871 of the network 862, an **ATM** connection 882 from the CLSF 871 to a CLSF 872 of a sub-network in the network 863 connected with the network 862, an **ATM** connection 883 from the CLSF 872 to a CLSF 873 of a sub-network in the network 863 connected with the terminal 87B, and an **ATM** connection 884 from the CLSF 873 to the terminal 87B.

DETD The terminal 87A carries out the **address resolution** of the network layer address of the terminal 87B to recognize that the terminal 87B belongs to the network 851, while also obtains the VCI/VPI data for transmitting the cell to the CLSF 871 in the manner similar to that described above. Then, the datagram is transmitted from this terminal 87A to the CLSF 871 through the **ATM** connection 881.

DETD The datagram and the **ATM** connection are terminated once by the CLSF 871 at which the layer 3 protocol processing for analyzing the network layer address of the datagram is carried out. As a result, it

is
recognized that the terminal 87B is present in the network 863, while also obtains the VCI/VPI data for transmitting the cell to the CLSF

872.
Then, the datagram is transmitted from this CLSF 871 to the CLSF 872 through the **ATM** connection 882.

DETD The datagram and the **ATM** connection are terminated again by the CLSF 872 at which the layer 3 protocol processing for analyzing the network layer address of the datagram is carried out, while the VCI/VPI data for transmitting the cell to the CLSF 873 is also obtained. Then, the datagram is transmitted from this CLSF 872 to the CLSF 873 through the **ATM** connection 883.

DETD The CLSF 873 which received the datagram then analyzes the network layer
address of the datagram to analyze the access address of the terminal 87B. Then, the cell with the appropriate VCI/VPI attached is transmitted
to the terminal 87B through the **ATM** connection 884.

DETD In this manner, the termination of the **ATM** connection and the network layer protocol processing are carried out three times to transmit the datagram from the terminal 87A to the terminal 87B.

DETD In this case, two **ATM** connections 891 and 892 as shown in FIG. 53 are required, including an **ATM** connection 891 from the terminal 87A of the network 861 to the CLSF 871 of the network 862, and an **ATM** connection from the CLSF 871 to the terminal 87C in the public network 864.

DETD The terminal 87A carries out the **address resolution** of the network layer address of the terminal 87C to recognize that the terminal 87C belongs to the network 851, while also obtains the VCI/VPI data for transmitting the cell to the CLSF 871 in the manner similar to that described above. Then, the datagram is transmitted from this terminal 87A to the CLSF 871 through the **ATM** connection 891.

DETD The datagram and the **ATM** connection are terminated once by the CLSF 871 at which the layer 3 protocol processing for analyzing the network layer address of the datagram is carried out. As a result, it

is

recognized that the terminal 87C is present in the network 864, while also obta● the VCI/VPI data for transmit●● the cell to the network VCI/VPI. Then, the datagram is transmitted from this CLSF 871 to the

IWU
provided between the networks 862 and 864 through the **ATM** connection 892.

DETD   In this manner, the termination of the **ATM** connection and the network layer protocol processing are carried out once to transmit the datagram from the terminal 87A to the network 864 containing the terminal 87C. Here, the datagram transmission target from the CLSF 871 may be the CLSF provided within the public network 864 if desired. In such a case, the termination of the **ATM** connection and the network layer protocol processing are carried out more than once.

DETD   In this case, five **ATM** connections 901 to 905 as shown in FIG. 54 are required, including an **ATM** connection 901 from the terminal 87A to a CLSF 874 within the network 861, an **ATM** connection 902 from the CLSF 874 to a CLSF 871 of the network 862, an **ATM** connection 903 from the CLSF 871 to a CLSF 872 of a sub-network in the network 863 connected with the network 862, an **ATM** connection 904 from the CLSF 872 to a CLSF 873 of a sub-network in the network 863 connected with the terminal 87B, and an **ATM** connection 905 from the CLSF 873 to the terminal 87B.

DETD   The terminal 87A carries out the **address resolution** of the network layer address of the terminal 87B to recognize that the terminal 87B belongs to the network 851 (or that the cell is to be transmitted to the CLSF 874), while also obtains the VCI/VPI data for transmitting the cell to the CLSF 874 in the manner similar to that described above. Then, the cell is transmitted from this terminal 87A

to
the CLSF 874 through the **ATM** connection 901.

DETD   The CLSF 874 which received this cell recognizes that there is a need

to
transmits the cell to the network 862 (or CLSF 871) according to the analysis of the network layer address of the datagram obtained either

by
the CLSF 874 itself or by the terminal 87A, while also obtains the VCi/VPI data for transmitting the cell to the CLSF 871. Them, the datagram is transmitted from this CLSF 874 to the CLSF 871 through the **ATM** connection 902.

DETD   The datagram and the **ATM** connection are terminated once by the CLSF 871 at which the layer 3 protocol processing for analyzing the network layer address of the datagram is carried out. As a result, it

is
recognized that the terminal 87B is present in the network 863, while also obtains the VCI/VPI data for transmitting the cell to the CLSF

872.
Then, the datagram is transmitted from this CLSF 871 to the CLSF 872 through the **ATM** connection 903.

DETD   The datagram and the **ATM** connection are terminated again by the CLSF 872 at which the layer 3 protocol processing for analyzing the network layer address of the datagram is carried out, while the VCI/VPI data for transmitting the cell to the CLSF 873 is also obtained. Then, the datagram is transmitted from this CLSF 872 to the CLSF 873 through the **ATM** connection 904.

DETD   The CLSF 873 which received the datagram then analyzes the network layer
address of the datagram to analyze the access address of the terminal 87B. Then, the cell with the appropriate VCI/VPI attached is transmitted
to the terminal 87B through the **ATM** connection 905.

DETD   In this manner, the termination of the **ATM** connection and the network layer protocol processing are carried out four (or three) times to transmit the datagram from the terminal 87A to the terminal 87B.

DETD   In this case, three **ATM** connections 911 to 913 as shown in FIG. 55 are required, including an **ATM** connection 911 from the

terminal 87A to a CLSF 874 within the network 861, an **ATM** connection 912 from the CLSF 874 to a CLSF ● of the network 862, and an **ATM** connection 913 from the CLSF 871 to the terminal 87C in the public network 864.

DETD   The terminal 87A carries out the **address resolution** of the network layer address of the terminal 87C to recognize that the terminal 87C belongs to the network 851 (or that the cell is to be transmitted to the CLSF 874), while also obtains the VCI/VPI data for transmitting the cell to the CLSF 874 in the manner similar to that described above. Then, the datagram is transmitted from this terminal 87A to the CLSF 874 through the **ATM** connection 911.

DETD   The CLSF 874 which received this cell recognizes that there is a need

to

    transmits the cell to the network 862 (or CLSF 871) according to the analysis of the network layer address of the datagram obtained either

by

    the CLSF 874 itself or by the terminal 87A, while also obtains the VCi/VPI data for transmitting the cell to the CLSF 871. Them, the datagram is transmitted from this CLSF 874 to the CLSF 871 through the **ATM** connection 912.

DETD   The datagram and the **ATM** connection are terminated once by the CLSF 871 at which the layer 3 protocol processing for analyzing the network layer address of the datagram is carried out. As a result, it

is

    recognized that the terminal 87C is present in the network 864, while also obtains the VCI/VPI data for transmitting the cell to the network VCI/VPI. Then, the datagram is transmitted from this CLSF 871 to the

IWU

    provided between the networks 862 and 864 through the **ATM** connection 913.

DETD   In this manner, the termination of the **ATM** connection and the network layer protocol processing are carried out twice (or once) to transmit the datagram from the terminal 87A to the network 864 containing the terminal 87C. Here, the datagram transmission target

from

    the CLSF 871 may be the CLSF provided within the public network 864 if desired. In such a case, the termination of the **ATM** connection and the network layer protocol processing are carried out more than twice.

DETD   Now, the embodiment in which the above described **ATM** communication system according to the present invention is applied for

a

    case of realizing a modified network layer topology independent from

the

    topology of the physical network will be described in detail.

DETD   FIG. 56 shows a configuration of the **ATM** communication system in this embodiment, which comprises: a first **ATM**-LAN 1101 containing M terminals 151 to 15M and a second **ATM**-LAN 1102 containing N terminals 121 to 12N which are inter-networking through an IWU 1111. Here, the first **ATM**-LAN 1101 has a CLSF 1112 for carrying out the processing for realizing the connection-less communication, whereas the second **ATM**-LAN 1102 has no CLSF.

DETD   The CLSF 1112 of the first **ATM**-LAN 1101 not only supports the datagram transmission among the terminals 151 to 15M of the first **ATM**-LAN 1101, but also the datagram transmission among the terminals among the terminals 121 to 12N of the second **ATM**-LAN 1102 as well, and to this end, at the network layer, the CLSF 1112 is given in advance the first address data indicating that it belongs to the first **ATM**-LAN 1101 in which it is physically located, as well as the second address data indicating that it also belongs to the second **ATM**-LAN 1102. These first and second address data will be referred hereafter as the network IDs.

DETD   The IWU 1111 inter-networking the first and second **ATM**-LANs 1101 and 1102 has a schematic configuration shown in FIG. 57 which includes a header conversion table 1172 and a header conversion unit

1173, where the header conversion table 1172 registers the relationship
between the header (or the connection identifier, i.e., VCI/VPI) of the
input cell from the ATM connection, and the header of the
output cell to the ATM connection, while the header conversion
unit 1173 converts the header of the input cell by looking up the
header
conversion table 172 and attaches the converted header to the output
cell.

DETD   In addition, the first and second ATM-LANs 1101 and 1102 have
call set up units 1113 and 1114, respectively. The call set up unit
1113
of the first ATM-LAN 1101 sets up the ATM
connections 141 to 14N between the IWU 1111 and the CLSF 1112, as well
as the ATM connections 161 to 16M between the CLSF 1112 and
the terminals 151 to 15M belonging to the first ATM-LAN 1101,
while the call set up unit 1114 of the second ATM-LAN 1102
sets up the ATM connections 131 to 13N between the IWU 1111
and the terminals 121 to 12N belonging to the second ATM-LAN
1102.

DETD   Now, the operation of this embodiment will be described for an
exemplary
case of realizing the connection-less communication from the terminal
1121 in the second ATM-LAN 1102 by using the CLSF 1112 in the
first ATM-LAN 1101. In this case, the second ATM-LAN
1102 containing this terminal 1121 has no CLSF for realizing the
connection-less communication itself, so that the CLSF 1112 of the
first
ATM-LAN 1101 is made to be also available for the terminal 1121
of the second ATM-LAN 1102 as described below.

DETD   First, at the step S11, in order to set up the ATM connection
between the terminal 1121 and the CLSF 1112, the call set up unit 1114
sets up the first ATM connection 1131 between the terminal
1121 and the IWU 1111. Then, at the step S12, the call set up unit 1114
makes the set up request for the ATM connection between the
IWU 1111 and the CLSF 1112 to the call set up unit 1113 of the first
ATM-LAN 1101, as the first and second ATM-LANs 1101
and 1102 are independent networks. Then, in response to this set up
request, at the step S13, the call set up 1113 sets up the ATM
connection 1141 between the IWU 1111 and the CLSF 1112.

DETD   Here, the method of making the ATM connection set up request
from the call set up unit 1114 to the call set up unit 1113 can be
either one of: (1) providing an ATM connection 1171 between
the call set up unit 1113 and the call set up unit 1114 in advance, and
the set up request is made directly through this ATM
connection 1171, or (2) terminating the set up request from the call
set
up unit 1114 once at the IWU 1111 and then relaying it to the call set
up unit 1113 from the IWU 1111.

DETD   When the ATM connections 1131 and 1141 are set up in this
manner, next at the step S14, the IWU 1111 connects these ATM
connections 1131 and 1141 at the ATM layer. In this case, the
header conversion table 1172 has registered entries such that: (a) the
header of the cell arriving from the ATM connection 1131 is
changed to the connection identifier (VCI/VPI) indicating the
ATM connection 1141, and (b) the header of the cell arriving
from the ATM connection 1141 is changed to the connection
identifier (VCI/VPI) indicating the ATM connection 1131. The
header conversion unit 1173 converts the header of the arriving cell by
looking up this header conversion table 1172, and transmits the cell
arriving from the ATM connection 1131 to the ATM
connection 1141, and the cell arriving from the ATM connection
1141 to the ATM connection 1131. In this manner, the
ATM connections 1131 and 1141 are connected at the ATM
layer by the IWU 1111.

DETD   Next, at the step S15, the datagram transmission between the terminal

1121 and the CLSF 1112 is carried out through the **ATM**
connection 1131 and 1141 connected at the ░ layer. In this
case, using the connection between the **ATM** connections 1131
and 1141, the datagram transmission can be realized by simply carrying
out the header conversion processing at the **ATM** layer in the
IWU 1111, for both of the datagram to be delivered from the terminal
1121 to the CLSF 1112 as well as the **ATM** cell assembled
datagram to be delivered from the CLSF 1112 to the terminal 1121.

DETD   First, in a case (1) of the datagram transmission from the terminal
1121
to the CLSF 1112, (1-1): the cell assembled datagram is transmitted to
the IWU 1111 from the terminal 1121 through the **ATM** connection
1131, (1-2): the IWU 1111 relays the cell arrived from the **ATM**
connection 1131 to the **ATM** connection 1141 by looking up the
header conversion table 1172, and (1-3): the CLSF 1112 receives the
cell
assembled datagram arriving from the **ATM** connection 1141.

DETD   On the contrary, in a case (2) of the datagram transmission from the
CLSF 1112 to the terminal 1121, (2-1): the cell assembled datagram is
transmitted to the IWU 1111 from the CLSF 1112 through the **ATM**
connection 1141, (2-2): the IWU 1111 relays the cell arrived from the
ATM connection 1141 to the **ATM** connection 1131 by
looking up the header conversion table 1172, and (2-3): the terminal
1121 receives the cell assembled datagram arriving from the **ATM**
connection 1131.

DETD   In this manner, it is possible in this embodiment to transmit the cell
directly at the network layer between the terminal 1121 and the CLSF
1112. The cell transmission between the CLSF 1112 and any of the other
terminals 1122 to 112N through the **ATM** connections 1132 to
113N and 1142 to 114N can also be realized similarly.

DETD   Next, an exemplary processing at the network layer in this embodiment
will be described with reference to FIG. 59 which indicates the
physical
regions of the **ATM** communication system of FIG. 56 along with
the logical regions at the network level and the logical connection
states among these logical regions.

DETD   Here, between the terminals 1121 to 112N of the second **ATM-LAN**
1102 and the CLSF 1112 of the first **ATM-LAN** 1101, the
ATM connections 1131 to 113N and 1141 to 114N are provided as in
FIG. 56, such that the datagram transmission can be realized in forms
of
the **ATM** cells between the CLSF1112 and the terminals 1121 to
112N. In addition, the **ATM** connections 1161 to 116M are also
provided between the CLSF 1112 and the terminals 1151 to 115M of the
first **ATM-LAN** 1101.

DETD   The CLSF 1112 has a datagram processing unit 1201 and an **ATM**
layer processing unit 1211, and the terminals 1121 to 112N have a data
processing unit 1202 and an **ATM** layer processing unit 1212.
The datagram processing unit 1201 operates according to the network ID
indicating that the CLSF 1112 belongs to the second **ATM-LAN**
1102 with respect to the input and output through the **ATM**
connections 1141 to 114N, or according to the network ID indicating
that
the CLSF 1112 belongs to the first **ATM-LAN** 1101 with respect
to the input and output through the **ATM** connections 1161 to
116M.

DETD   In this case, the datagram outputted from the datagram processing unit
1202 within the terminals 1121 to 112N is cell assembled at the
ATM layer processing unit 1212 within the terminals 1121 to
112N, and reaches to the CLSF 1112 without being re-constructed into
the
datagram form before being cell disassembled at the **ATM** layer
processing unit 1211 within the CLSF 1112. Similarly, the datagram
outputted from the datagram processing unit 1201 within the CLSF 1112
is

cell assembled at the **ATM** layer processing unit 1211 within
the terminals 1121 to 112N, and reaches to terminals 1121 to 112N
without being re-constructed into the datagram form before being cell
disassembled at the **ATM** layer processing unit 1212 within the
terminals 1121 to 112N.

DETD   In this manner, the direct delivery (i.e., the delivery without looking
up the network layer data in a middle) of the datagram at the network
layer between the terminals 1121 to 112N and the CLSF 1112 is
supported,
so that there is no need for the datagram processing unit 1202 within
the terminals 1121 to 112N to recognize the fact that the CLSF 1112 is
actually located in the physically separated first **ATM-LAN**
1101. Similarly, there is no need for the datagram processing unit 1201
within the CLSF 1112 to recognize the fact that the terminals 1121 to
112N are actually located in the physically separated second **ATM**
-LAN 1102.

DETD   Here, the network layer address is given in a form shown in FIG. 60 in
which the network ID described above is multiplexed with the terminal
ID
indicating the specific address of each terminal. The CLSF 1112 has two
sets of network IDs in correspondence to the first and second
ATM-LANs 1101 and 1102, which are shared with the terminals
within the respective **ATM**-LANs 1101 and 1102. It is noted that
the order of the network ID and the terminal ID in the network layer
address may be reversed from that shown in FIG. 60 if desired.

DETD   It is also noted that the scheme for providing two sets of network IDs
to be CLSF 1112 with respect to the first and second **ATM**-LANs
1101 and 1102 is adopted in this embodiment because of the easiness of
its implementation, but it is also possible to adopt the scheme in
which
the CLSF 1112 (i.e., the network address belonging to the first
ATM-LAN 1101 which has the CLSF 1112) can be made to appear as
if it is virtually belonging to the second **ATM**-LAN 1102 by
operating the CLSF 1112 and the terminals 1121 to 112N accordingly at a
time of mapping the **ATM** layer and executing the network layer
protocol.

DETD   By setting up the network layer address in this manner, it becomes
possible at the network layer to handle the CLSF 1112 within the first
ATM-LAN 1101 as if it is belonging to the second **ATM**
-LAN 1102 as well such that the terminals 1121 to 112N and the CLSF
1112
can be treated as if they are belonging to the same network. Namely,
the
logical region of the second **ATM**-LAN 1102 at the network layer
includes the physical region 1221 of the second **ATM**-LAN 1102
as well as the **ATM** connections 1141 to 114N and the CLSF 1112,
as indicated by the hatched area in FIG. 59. In this case, the logical
region of the first **ATM**-LAN 1101 at the network layer is going
to be the physical region of the first **ATM**-LAN 1101 from which
the **ATM** connections 1141 to 114N are excluded, so that the
CLSF 1112 logically belongs to both of the first and second **ATM**
-LANs 1101 and 1102. Here, however, it is to be noted that these
logical
regions are valid only for the network layer of the connection-less
communication (datagram communication), and the logical regions for the
ATM layer and the logical regions for the network layer of the
connection oriented communication are generally different from the
logical regions in the connection-less communication.

DETD   In this manner, for the connection-less communication, the logical
regions at the network layer which is different from the physical
regions of the **ATM**-LANs to realize the network layer topology
1231 shown in FIG. 59 in which the CLSF 1112 can be treated as a router
(or a gate-way).

DETD   Therefore, when the routing protocol is executed among the CLSFs, the
CLSF 1112 logically appears at the network layer as if it is located in

the **ATM-LAN** which physically contains no CLSF. Consequently,
even when the already existing routing protocol is executed as it is,
the route selected by the routing protocol and the route passing
through
    the CLSF 1112 coincides, so that the consistent connection-less
communication can be realized. In this case, it suffices for the IWU
1111 to pass the routing data for the connection-less communication, so
that the IWU 1111 can be totally free from the routing in the
connection-less communication.

DETD   FIG. 61 shows another network topology which can be handled in the
manner similar to that described above. In this FIG. 61, three
ATM-LANs 1301 to 1303 are inter-networking through IWUs (not
shown) with the CLSF 1331, where the CLSF 1331 physically belongs to
the
    ATM-LAN 1301. In this case, by setting up the network layer
address in the manner similar to that described above, it becomes
possible to make the CLSF 1331 to appear as if it is also logically
belonging to the **ATM**-LANs 1302 and 1303. Consequently, it
becomes possible to realize the logical network layer topology in which
the **ATM**-LANs 1301 to 1303 are inter-networking with the CLSF
1331 as a router (or a gate-way).

DETD   Now, the manner of executing the routing protocol among the CLSFs in
more general case of this embodiment will be described with references
to FIGS. 62 and 63. Here, the network configuration of FIG. 56 is
expanded such that seven **ATM**-LANs 1401 to 1407 are
inter-networking through six IWUs 1411 to 1416 as shown in FIG. 62,
where only the **ATM**-LANs 1401, 1403, and 1406 contain the CLSFs
1421 to 1423, respectively, while the other **ATM**-LANs 1402,
1404. 1405, and 1407 have no CLSF physically. Here, however, by setting
the network layer addresses as in the above, at the network layer
level,
    the CLSF 1421 logically belongs to the **ATM**-LAN 1402, the CLSF
1422 logically belongs to the **ATM**-LAN 1404 and 1405, and the
CLSF 1423 logically belongs to the **ATM**-LAN 1407.

DETD   In this case, the **ATM** connection 1441 is set up between the
CLSFs 1421 and 1422, while the IWU 1412 which is inter-networking the
ATM-LANs 1401 and 1403 has a function for passing the data as it
is with respect to the data transmission including that of the routing
data between the CLSFs 1421 and 1422.

DETD   Similarly, the **ATM** connection 1442 is set up between the CLSFs
1421 and 1423, while the IWU 1415 which is inter-networking the
ATM-LANs 1401 and 1406 has a function for passing the data as it
is with respect to the data transmission including that of the routing
data between the CLSFs 1421 and 1423.

DETD   Here, a scheme for setting up the **ATM** connections 1441 and
1442 can be either one of a scheme for setting up one **ATM**
connection for the transmission of the datagram as well as the control
data such as the routing data between the CLSFs, or a scheme for
setting
    up different **ATM** connections for the datagram transmission and
the transmission of the control data such as the routing data between
the CLSFs.

DETD   Namely, the CLSF 1422 notifies the CLSF 1421 that "**ATM**-LANs
1403, 1404, and 1405 can be reached by one hop" as the **ATM**
-LANs 1403, 1404, and 1405 are the networks to which the CLSF 1422 can
deliver the datagram directly. The CLSF 1423 similarly notifies the
CLSF
    1421 that "**ATM**-LANs 1406 and 1407 can be reached by one hop"
as the **ATM**-LANs 1406 and 1407 are the networks to which the
CLSF 1423 can deliver the datagram directly. Also, the CLSF 1421
notifies the CLSFs 1422 and 1423 that "**ATM**-LANs 1401 and 1402
can be reached by one hop" as the **ATM**-LANs 1401 and 1402 are
the networks to which the CLSF 1421 can deliver the datagram directly.

DETD   In addition, when the routing data from the CLSFs 1422 and 1423 have
reached to the CLSF 1421 at this point, the CLSF 1421 notifies the
CLSFs

1422 and 1423 that "**ATM**-LANs 1403 to 1407 can be reached by
two hops' ⬤ adding one hop to the routing ⬤ ta reached from the CLSFs
1422 and ⬤23.

DETD   Here, the CLSFs 1421 to 1423 have associated routing tables 1451 to
1453

        which indicate the correspondence relationship between the datagram
destination and the delivering target **ATM**-LAN (transmission
target) in a case of operating the RIP at the CLSFs 1421 to 1423. Thus,
each of the CLSFs 1421 to 1423 calculates the route from the received
routing data and selects the shortest route in order to determine the
delivering target for the datagram. In the routing tables 1451 to 1451
to 1453, the entry with "direct delivery" registered as the delivery
target indicates the network which can be reached by 0 hop.

DETD   For example, in a case of the CLSF 1421, the routing table 1451 is
constructed according to the routing data indicating that: (1) the
ATM-LANs 1401 and 1402 can be delivered directly by itself, (2)
the **ATM**-LANs 1403, 1404, and 1405 can be reached by one hop
from the CLSF 1422, and (3) the **ATM**-LANs 1406 and 1407 can be
reached by one hop from the CLSF 1423.

DETD   For example, in a case of the CLSF 1422, the routing table 1452 is
constructed according to the routing data indicating that: (1) the
ATM-LANs 1403, 1404, and 1405 can be delivered directly by
itself, (2) the **ATM**-LANs 1401 and 1402 can be reached by one
hop from the CLSF 1421, and (3) the **ATM**-LANs 1403, 1404. 1405,
1406, and 1407 can be reached by two hops from the CLSF 1421. Here, for
the **ATM**-LANs 1403, 1404, and 1405, the directly delivering
route is going to be the shortest route, so that the directly
delivering
route is registered in the routing table 1452.

DETD   For example, in a case of the CLSF 1423, the routing table 1453 is
constructed according to the routing data indicating that: (1) the
ATM-LANs 1406 and 1407 can be delivered directly by itself, (2)
the **ATM**-LANs 1401 and 1402 can be reached by one hop from the
CLSF 1421, and (3) the **ATM**-LANs 1403, 1404, 1405, 1406, and
1407 can be reached by two hops from the CLSF 1421. Here, for the
ATM-LANs 1406 and 1407, the directly delivering route is going
to be the shortest route, so that the directly delivering route is
registered in the routing table 1453.

DETD   The procedure for carrying out the connection-less communication over
the **ATM**-LANs using these routing tables 1451 to 1453 will be
described with reference to FIG. 63, for an exemplary case of the
datagram transmission from the terminal 1461 belonging to the
ATM-LAN 1404 to the terminal 1462 belonging to the **ATM**
-LAN 1407. In this case, by the call set up units provided in the
networks, the **ATM** connection 1443 between the terminal 1461
and the CLSF 1422 and the **ATM** connection 1444 between the
terminal 1462 and the CLSF 1423 are set up in advance in the manner
described above.

DETD   At the terminal 1461, the data from the application is processed to
obtain the datagram to be transmitted to the terminal 1462 at the
datagram processing unit 4611, and the cell is assembled from the
datagram at the cell assembling unit 4612, and the assembled cell is
outputted from the cell transmission unit 4613. The cell outputted from
the terminal 1461 then reaches to the CLSF 1422 through the **ATM**
connection 1443.

DETD   At the CLSF 1422, the arrived cell is received at the cell reception
unit 4221, and the cell is disassembled at the cell disassembling unit
4222, and the datagram is reproduced at the datagram processing unit
4223, and then the network ID of the transmission target given in a
form

        shown in FIG. 60 is transmitted to the routing protocol execution unit
4224. At the routing protocol execution unit 4224, according to this
network ID, it can be recognized that the terminal 1462 belongs to the
ATM-LAN 1407, so that the routing table 1452 is looked up to
determine the delivery target as the CLSF 1421. Then, the **ATM**

address search unit 4225 looks up the **ATM** address table 1472
according ● the network ID of the CLSF 142 ● o obtain the VCI/VPI

value

appropriate for the datagram transmission to the CLSF 1421, and
transmits the obtained VCI/VPI value to the cell assembling unit 4226.
The cell assembling unit 4226 then assembles the cell from the payload
including the datagram transmitted from the datagram processing unit
4223 according to the routing data supplied from the routing protocol
execution unit 4224 and the VCI/VPI value supplied from the **ATM**
address search unit 4225, and the assembled cell is outputted from the
cell transmission unit 4227.

DETD   The cell outputted from the CLSF 1422 is then transmitted to the CLSF
1421 through the **ATM** connection 1441 and the IWU 1412 provided
between the CLSFs 1421 and 1422. The IWU 1412 only applies the
ATM layer processing (which is the processing requiring no cell
re-assembling) to the cell from the CLSF 1422 and pass it to the CLSF
1421.

DETD   At the CLSF 1421, the processing similar to that carried out at the
CLSF

1422 is carried out, and the routing table 1451 is looked up to
determine the delivery target as the CLSF 1423. Then, the cell is
assembled by obtaining the appropriate VCI/VPI value from the
ATM address table 1471, and the assembled cell is outputted to
the CLSF 1423. The cell outputted from the CLSF 1421 is then
transmitted
to the CLSF 1423 through the **ATM** connection 1442 and the IWU
1415 provided between the CLSFs 1421 and 1423.

DETD   At the CLSF 1423, the processing similar to that carried out at the
CLSF

1421 is carried out, and the routing table 1453 is looked up to
recognize that the delivery target can be delivered directly (as the
CLSF 1423 itself is registered as the delivery target by the RIP),
i.e.,

the destination is the terminal 1462 which is directly connected by the
ATM connection from the CLSF 1423. Then, by looking up the
ATM address table 1473, the **ATM** connection 1444 is
registered In correspondence to the terminal 1462, so that the CLSF
1423

outputs the cell assembled from the datagram to the terminal 1462
through the **ATM** connection 1444. The cell outputted from the
CLSF 1423 is then transmitted to the terminal 1462 through the
ATM connection 1444 and the IWU 1416 provided between the CLSF
1423 and the terminal 1462.

DETD   At the terminal 1462, the cell arriving through the **ATM**
connection 1444 is received at the cell reception unit 4621, the cell
is

disassembled at the cell disassembling unit 4622, and the datagram is
reconstructed at the datagram processing unit 4623, and the
re-constructed datagram is transmitted to the application.

DETD   In this manner, the datagram transmission over the **ATM**-LANs
using the routing protocol can be realized. Here, as for the routing
protocol which is operated among the CLSFs, the the routing data is
cell

assembled by the routing protocol execution unit within the CLSF, while
also supplied to the other CLSFs connected though the **ATM**
connections, and the CLSF which received the routing data re-constructs
the datagram at the datagram processing unit within the CLSF, and
transmits the routing data to the routing protocol execution unit.

DETD   Next, a scheme for transmitting the routing data from the CLSF to the
ATM-LAN in which the CLSF is absent will be described with
reference to FIG. 64, the **ATM**-LANs 1501 and 1502 are
inter-networking through the IWU 1511, where the **ATM**-LAN 1501
has the CLSF 1521 while the **ATM**-LAN 1502 has no CLSF. Here,
the CLSF 1521 is logically connected with the **ATM**-LAN 1502 as
in the above such that the CLSF 1521 can appear to be logically present

in the **ATM**-LAN 1502 as well. Although not shown in FIG. 64,
the **ATM-I**⬤ 1501 and 1502 are also conne⬤ with the other
ATM-LANs through the IWUs, and the CLSF 1521 is executing the
routing protocol.

DETD The CLSF 1521 transmits the routing data to the device 1531 which
requires the routing data within the **ATM**-LAN 1501 in which the
CLSF 1521 is contained as well as to the device 1532 which requires the
routing data within the **ATM**-LAN 1502 which logically belongs
to the same network as the **ATM**-LAN 1501. Here, the devices
1531 and 1532 which require the routing data can be any of the datagram
terminals, the **address resolution server**
(ARS) for setting a correspondence between the network ID and the
VCI/VPI, and the IWU.

DETD In this case, the routing data to the device 531 can be delivered from
the CLSF 1521 as it is within the **ATM**-LAN 1501 as this device
1531 is located within the **ATM**-LAN 1501 in which the CLSF 1521
is also located.

DETD On the other hand, in order to deliver the routing data from the CLSF
1521 to the **ATM**-LAN 1502, it suffices for the IWU 1511
provided between the CLSF 1521 and the **ATM**-LAN 1502 to pass
the routing data transmitted from the CLSF 1521 to the device 532 as it
is, because there is no need to process the routing data as the CLSF
1521 also belongs to the **ATM**-LAN 1502 at the network layer. To
this end, there is a need for the CLSF 1521 and the device 1532 to be
connected at the **ATM** layer even when the IWU 151 is located
therebetween. This can be achieved by using the **ATM** connection
for the logical connection as in the above, or by setting up the
separate **ATM** connection for the routing data transmission.

DETD As an example, a case of using the RIP described above will be
described. In this case, as shown in FIG. 64, the CLSF 1521 has the
routing table 1541, and the devices 1531 and 1532 which require the
routing data are executing the RIP to make the passive operation (i.e.,
the operation in which the routing data is received and processed, but
not transmitted to the others). In this case, according to the routing
data received from the CLSF 1521, the device 1531 within the **ATM**
-LAN 1501 can construct the routing table 1551, while the device 1532
within the **ATM**-LAN 1502 can construct the routing table 1552.

DETD When these routing tables 1551 and 1552 are constructed, they can
function as means for selecting the direct datagram transmission
without
passing through CLSF when the destination terminal is located within
the
same **ATM**-LAN.

DETD Now, FIG. 65 shows another configuration of the **ATM**
communication system in this embodiment, which comprises: a first
ATM-LAN 1601 containing N terminals 1631 to 163N, a second
ATM-LAN 1602 containing N terminals 1641 to 164N, and a third
ATM-LAN 1603 containing N terminals 1651 to 165N, where the
first and second **ATM**-LANs 1601 and 1602 are inter-networking
through an IWU 1611, and the second and this **ATM**-LANs 1602 and
1603 are inter-networking through an IWU 1612. Here, the first
ATM-LAN 1601 has a CLSF 1613 for carrying out the processing for
realizing the connection-less communication, whereas the second and
third **ATM**-LANs 1602 and 1603 have no CLSF.

DETD In addition, the **ATM**-LANs 1601, 1602, and 1603 have call set
up units 1616, 1615, and 1614, respectively. The call set up unit 1113
of the first **ATM**-LAN 1101 sets up the **ATM**
connections 141 to 14N between the IWU 1111 and the CLSF 1112, as well
as the **ATM** connections 161 to 16M between the CLSF 1112 and
the terminals 151 to 15M belonging to the first **ATM**-LAN 1101,
while the call set up unit 1114 of the second **ATM**-LAN 1102
sets up the **ATM** connections 131 to 13N between the IWU 1111
and the terminals 121 to 12N belonging to the second **ATM**-LAN
1102.

DETD The CLSF 1613 of the first **ATM**-LAN 1601 not only supports the

datagram transmission among the terminals (not shown) of the first ATM-LAN 16●● but also the datagram transmi●●n among the terminals among the terminals (not shown) of the second ATM-LAN 1602 and the datagram transmission among the terminals among the terminals 1621 to 162N as well, and to this end, at the network layer, the CLSF 1112 is given not only the first network ID indicating that it belongs to the first ATM-LAN 1601 in which it is physically located, as well as the second and third network IDs indicating that it also belongs to the second and third ATM-LANs 1602 and 1603. In this manner, the CLSF 1613 can be made to appear as if it is in the second ATM-LAN 1602 or the third ATM-LAN 1603.

DETD   In this case, the connection-less communication (datagram transmission) between the CLSF 1613 and the terminals 1621 to 162N in the ATM-LAN 1603 requires the passing through two IWUs 1611 and 1612. This operation will now be described.

DETD   Here, as described above, the ATM-LAN 1603 has no CLSF, so that it is necessary to make the CLSF 1613 in the ATM-LAN 1601 to be available to the terminals in the ATM-LAN 1603. In the following, an exemplary case of the datagram transmission from the terminal 1621 in the ATM-LAN 1603 will be described.

DETD   First, at the step S21, in order to set up the ATM connection between the terminal 1621 and the CLSF 1613, the call set up unit 1614 sets up the ATM connection 1631 between the terminal 621 and the IWU 1612. Then, at the step S22, the call set up unit 1614 makes the
ATM connection set up request to the call set up unit 1615 in the ATM-LAN 1602 which is the independent network from the ATM-LAN 1603 to which the call set up unit 1614 belongs.

DETD   Here, however, the ATM-LAN 1602 also has no CLSF, so that the call set up request unit 1615 which received the ATM connection set up request from the call set up unit 1614 sets up the ATM connection 1641 between the IWU 1612 and the IWU 1611 at the step S23, and makes the call set up request for the CLSF 1613 to the call set up unit 1616 in the neighboring ATM-LAN 1601 at the step S24. Then, the call set up unit 1616 sets up the ATM connection 1651 between the IWU 1611 and the CLSF 1613 in response to the received call set up request at the step S25.

DETD   When the ATM connections 1631, 1641, and 1651 are set up in this manner, next at the step S26, the IWU 1612 connects the ATM connections 1631 and 1641 at the ATM layer, while the IWU 1611 connects the ATM connections 1641 and the 1651 at the
ATM layer in the same manner as in the above.

DETD   Then, at the step S27, the datagram transmission between the terminal 1621 and the CLSF 1613 is carried out through the ATM connections 1631, 1641, and 1651 connected at the ATM layer in terms of the ATM cells.

DETD   The similar procedure can also be followed for the other terminals 1622 to 162N, to set up the ATM connections 1632 to 163N 1642 to 164N, and 1652 to 165N, connect the ATM connections 1632 to 163N and the ATM connections 1642 to 164N at the IWU 1612, connect the ATM connections 1642 to 164N and the ATM connections 1852 to 165N at the IWU 1611, and carry out the datagram transmissions in terms of the ATM cells between the terminals 1622 to 162N to the CLSF 1613.

DETD   By setting up the ATM connections in this manner, it becomes possible to carry out the direct datagram delivery at the network layer between the terminals 1621 to 162N and the CLSF 1613.

DETD   Thus, by setting the ATM connections between the terminals 1621 to 162N and the CLSF 1613, and assigning the network ID for the ATM-LAN 1603 to the CLSF 1613 as well, it becomes possible to realize the connection-less communication between the ATM-LANs which are logically connected over more than one IWUs.

DETD   Next, another embodiment in which the above described ATM communication system according to the present invention is applied for
a

case of realizing a modified network layer topology independent from the

topology of the physical network will be described in detail.

DETD   FIG. 67 shows a configuration of the **ATM** communication system in this embodiment, which comprises: first, second, and third **ATM**-LANs 1701, 1702, and 1703, where the first and second **ATM**-LANs 1701 and 1702 are inter-networking through an IWU 1711 while the second and third **ATM**-LANs 1702 and 1703 are inter-networking through an IWU 1712. Here, the first and second **ATM**-LANs 1701 and 1702 have CLSFs 1721 and 1722, respectively, whereas the third **ATM**-LAN 1703 has no CLSF.

DETD   The third **ATM**-LAN 1703 is logically connected with the CLSF 1722 in the second **ATM**-LAN 1702 as indicated by a logical connection 1731 in the same manner as in the above. Moreover, the third **ATM**-LAN 1703 is also logically connected with the CLSF 1721 in the first **ATM**-LAN 1701 which is separated by more than one hops in terms of the number of the IWUs as indicated by a logical connection 1732 tunnelling through the IWUs 1711 and 1712, as in the case of FIG. 65 described above. Thus, the third **ATM**-LAN 1703 logically has two CLSFs.

DETD   The CLSF 1721 has the **ATM**-LANs 1701 and 1703 as the networks to which it can make the direct delivery, so that it notifies the CLSF 1722 that "**ATM**-LANs 1701 and 1703 can be reached by one hop". The CLSF 1722 has the **ATM**-LANs 1702 and 1703 as the networks to which it can make the direct delivery, so that it notifies the CLSF 1721 that "**ATM**-LANs 1702 and 1703 can be reached by one hop".

DETD   By this data exchange, the routing table 1751 is constructed at the CLSF

1721 and the routing table 1752 is constructed at the CLSF 1722. In addition, the **ATM**-LAN 1703 eventually receives the routing data indicating that "**ATM**-LAN 1701 can be reached by one hop" and "**ATM**-LAN 1702 can be reached by two hops" from the CLSF 1721, as well as the routing data indicating that "**ATM**-LAN 1701 can be reached by two hops" and "**ATM**-LAN 1702 can be reached by one hop" from the CLSF 1722. Then, the device 1741 in the **ATM**-LAN 1703 which is making the passive operation can construct the routing table 1753 indicating that "the datagram destined to the **ATM**-LAN 1701 should be transmitted to the CLSF 1721" and "the datagram destined to the **ATM**-LAN 1702 should be transmitted to the CLSF 1722" according to these routing data received by the **ATM**-LAN 1703.

DETD   As for the other **ATM**-LANs 1701 and 1702, each of them has only one CLSF connected, so that there is no choice of the CLSFs available. However, each of them can be modified to provide the choice of the CLSFs

similarly to the **ATM**-LAN 1703 by providing the logical connection between the **ATM**-LAN 1702 and the CLSF 1721 or the logical connection between the **ATM**-LAN 1701 and the CLSF 1722, if desired.

DETD   Now, a scheme for setting up the **ATM** connection between the IWU and the CLSF in this embodiment will be described with reference to FIG. 68. In this case, the **ATM**-LANs 1801 and 1802 are inter-networking through the IWU 1811, and the **ATM**-LAN 1801 contains the CLSF 1821, while the **ATM**-LAN 1802 is logically connected with the CLSF 1821 in the **ATM**-LAN 1801 as in the above.

DETD   Between the CLSF 1821 and the IWU 1811, as many **ATM** connections (which define VCs) 1831 to 183N as a number N of terminals belonging to the **ATM**-LAN 1802 are set up. By bundling these VCs 1831 to 183N together as one VP 1841, it becomes possible for the **ATM**-LAN 1801 to realize the cell transmission between the CLSF 1821 and the IWU 1811 by only looking up the 8 bits VPI indicating the VP 1841, without looking up the 16 bits VCI.

DETD   In addition, by directly connecting each connection of the VCs 1831 to 183N in the VP 1841 with the already established **ATM**

connection (not shown) between the IWU 1811 and the terminal in the
ATM-LAN 18● at the ATM layer by the IWU 18● the
cell transmission from the terminal in the ATM-LAN 1802 to the
CLSF 1821 can be realized as the IWU 1811 carries out the relaying of
the cell from the ATM connection 1851 to the ATM
connection given by one of the VCs 1831 to 183N in the VP 1841. In
addition, for the cells transmitted from the CLSF 1821 to the terminal
in the ATM-LAN 1802, the IWU 1811 also carries out the
relaying of the cell for the ATM connection between the IWU
1811 and the terminal in the ATM-LAN 1802 by looking up the
VCI field, to realize the cell transmission between the CLSF 1821 and
the terminal in the ATM-LAN 1802 in a case of using the
bundling of the VCs 1831 to 183N into the VP 841.

DETD   Next, a scheme for setting up the ATM connection between the
IWU and the CLSF in this embodiment in a case of involving the
connection between the ATM-LANs which are separated by more
than one hops in terms of the number of IWUs will be described with
reference to FIG. 69. In this case, the ATM-LANs 1901, 1902,
and 1903 are provided, where the ATM-LANs 1901 and 1902 are
inter-networking through the IWU 1911 while the ATM-LANs 1902
and 1903 are inter-networking through the IWU 1912, and the ATM
-LAN 1901 contains the CLSF 1921, while the ATM-LANs 1902 and
1903 are logically connected with the CLSF 1921 in the ATM-LAN
1901 as in the above.

DETD   Between the CLSF 1921 and the IWU 1911, as many ATM
connections which define VCs 1931 to 193M as a number M of terminals
belonging to the ATM-LAN 1902 are set up, along with as many
ATM connections which define VCs 1941 to 194N as a number N of
terminals belonging to the ATM-LAN 1903.

DETD   By bundling these VCs 1931 to 193M and 1941 to 194N together as one VP
1941, it becomes possible for the ATM-LAN 1901 to exchange the
datagrams destined to the ATM-LANs 1902 and 1903 which are
outputted from the CLSF 1921 to the IWU 1911 and the datagrams from the
terminals in the ATM-LANs 1902 and 1903 by the 8 bits VPI
indicating the VP 1951.

DETD   In addition, the terminals in the ATM-LAN 1902 and the VCs
1931 to 193M bundled into the VP 1951 set up between the the IWU 1911
and the CLSF 1921, as well as the VCs 1961 and 196N set up between the
IWUs 1911 and 1912 and the VCs 1941 to 194N bundled into the VP 1951
are
directly connected at the ATM layer by the IWU 1911. For this
reason, for the VP 1951, the IWU 1911 sets whether it is the tunnelling
to the IWU 1912 or the delivery to the ATM-LAN 1902, according
to the VCI values of those which have arrived from the CLSF 1921. Also,
for those which have arrived from the terminals in the ATM-LAN
1902, the IWU 1911 is set to carry out the relaying of the cells to the
connection (not shown) between the terminals in the ATM-LAN
1902 and the IWU 1911 and the ATM connections indicated by the
VP 1951 and the VCs 1931 to 193M, and for those which have arrived from
the IWU 1912, the IWU 1911 is set to carry out the relaying of the
cells
to the VP 1951 and the VCs 1941 to 194N.

DETD   By these settings, in a case of involving the connection of the
ATM-LANs which are separated by more than one hops in terms of
the number of IWUs, the ATM connections between the CLSF 1921
and the IWU 1911 can be bundled together.

DETD   Similarly, in the ATM-LAN 1902, for those which are to be
tunnelled to the IWU 1912 among the above described VCs, by bundling
the
VCs 1961 to 196N in the ATM-LAN 1902 into one VP 1952, they
can be exchanged with the IWU 1912 by only looking up the 8 bits VPI
indicating the VP 1952.

DETD   Next, a method for judging whether it is the tunnelling to the IWU 1912
or the delivery to the terminals in the ATM-LAN 1902 will be
described.

DETD   The upper P bits 1972 of the VCI indicating the VCs 1931 to 193M and
the
        VCs 1941 to 194N between the IWU 1911 and the CLSF 1921 are used as the
        network identification, and set up such that it is possible to judge
        whether it is the delivery to the terminals in the **ATM**-LAN
        1902 or the tunnelling to the IWU 1912 according to the value of these
        VCI upper P bits 1972 at the IWU 1911. In a case of the delivery to the
    ATM-LAN 1902, they are converted into the VCI/VPI between the
        IWU 1911 and the terminals in the **ATM**-LAN 1902 by the VCI
        lower (18-P) bits 1973 and the cell is outputted to the terminals.
        Namely, the transmission target terminal is identified according to the
        VCI lower (16-P) bits 1973. In a case of the tunnelling to the IWU
1912,
        the cell is outputted to the VP for the tunnelling to the IWU 1912.
        Here, for the VCI value, any of (1) changing only the upper P bits of
        the VCI, (2) changing all of the VCI, and (3) not changing the VCI, can
        be selected appropriately.
DETD   For the cell arriving from the terminals in the **ATM**-LAN 1902,
        the relaying of the cells to the **ATM** connections indicated by
        the VCs 1931 to 193M in the VP 1951 is carried out at the IWU 1911. In
        this case, the **ATM** connections set up between the IWU 1911 and
        the terminals in the **ATM**-LAN 1902 and the VCs 1931 to 193M are
        directly connected in the IWU 1911. At this point, the header value to
        be assigned to the VCs 1931 to 193N may be the same value or the
        different value as the value of the **ATM** connection from the
        CLSF 1921 to the IWU 1911.
DETD   As for the cell transmitted from the IWU 1912 to the IWU 1911, the
        relaying of the cells to the **ATM** connections indicated by the
        VCs 1941 to 194N in the VP 1951 is carried out at the IWU 1911. At this
        point, the value of the VCs 1941 to 194N may be the same value or the
        different value as the value of the **ATM** connection from the
        CLSF 1921 to the IWU 1911.
DETD   As for the cells which are tunnelled, by using the format of the cell
        header 1971 in the **ATM**-LAN 1902, and carrying out the same
        processing as the IWU 1911 at the IWU 1912, the IWU can pass the cell
by
        the same processing for the networks which are separated by more than
        two hops in terms of the number of IWUs.
DETD   Here, the VCI upper P bits 1972 can have an optional number of bits P,
        and the number of **ATM**-LANs that can be contained and the
        number of terminals in the **ATM**-LAN without the CLSF are varied
        according to the value of P. In a case the connections between the IWU
        and the CLSF are bundled into one VP, the number of terminals to which
        the CLSF can make the direct delivery is going to be 2.sup.16
regardless
        of the value of P.
DETD   Next, a method of carrying out the broadcast between the CLSF and the
    ATM-LANs which are logically connected with CLSF as in the above
        will be described with reference to FIG. 71.
DETD   In FIG. 71, the **ATM**-LANs 1001 and 1002 are inter-networking
        through the IWU 1011, and the **ATM**-LAN 1001 contains the CLSF
        1021, while the **ATM**-LAN 1002 is logically connected with the
        CLSF 1021 as in the above, and as many **ATM** connections 1031 as
        the number of terminals belonging to the **ATM**-LAN 1002 are
        provided as the **ATM** connections between the CLSF 1021 and the
        IWU 1011. In addition, the **ATM** connection 1041 for broadcast
        is also provided, and this **ATM** connection 1041 is directly
        connected at the **ATM** layer to the broadcast channel at the
    ATM-LAN 1002.
DETD   In a case the CLSF 1021 makes the broadcast with respect to the
    ATM-LAN 1002, first the CLSF 1021 transmits the broadcast cell
        to the **ATM** connection 1041 for broadcast. This **ATM**
        connection 1041 is not for the broadcast in the **ATM**-LAN 1001,
        so that the broadcast is not carried out in the **ATM**-LAN 1001.
        At the IWU 1011, the cells transmitted from the **ATM** connection

1041 for broadcast are outputted to the broadcast channel of the ATM-LAN 1002. By this, the the cells in the ATM-LAN 1002 is broadcasted through the broadcast channel in the ATM-LAN 1002.

DETD On the other hand, as for the broadcast cells generated from the terminals in the ATM-LAN 1002, the broadcast cells may be made to arrive at the CLSF 1021 as well by outputting them to the ATM connection 1041 for broadcast at the IWU 1011.

DETD By this method, the transmission and reception of the broadcast cells between the CLSF 1021 and the ATM-LAN 1002 can be realized without loading the ATM-LAN 1001 which contains the CLSF 1021.

DETD Next, a method of carrying out the broadcast between the CLSF and the ATM-LANs which are logically connected with CLSF and separated by more than one hops in terms of the number of IWUs will be described with reference to FIG. 72.

DETD In FIG. 72, the ATM-LANs 2101 and 2102 are inter-networking through the IWU 2111, and the ATM-LANs 2102 and 2103 are inter-networking though the IWU 2112. The ATM-LAN 2101 contains the CLSF 2121, while the ATM-LANs 2102 and 2103 are logically connected with the CLSF 2121 as in the above.

DETD Between the CLSF 2121 and the IWU 2111, as many ATM connections (not shown) as the number of terminals belonging to the ATM-LAN 2102 are set up, and between the CLSF 2121 and the IWU 2111 and between the IWU 2111 and the IWU 2112, as many ATM connections 2131 and 2141, respectively, as the number of the terminals belonging to the ATM-LAN 2103 are set up, where the ATM connections 2131 and 2141 are directly connected at the ATM layer by the IWU 2111.

DETD In addition, the ATM connection 2161 for broadcast is provided between the IWUs 2111 and 2112, and the ATM connection 2151 for broadcast is provided between the IWU 2111 and the CLSF 2121, where these ATM connections 2161 and 2151 are directly connected at the ATM layer by the IWU 2111. Also, the ATM connection 2161 for the broadcast in the ATM-LAN 2103 is directly connected with the broadcast channel In the ATM-LAN 2103 at the ATM layer by the IWU 2112.

DETD In a case the CLSF 2121 makes the broadcast with respect to the ATM-LAN 2103, the CLSF 2121 transmits the broadcast cell to the IWU 2111 through the ATM connection 2151 for broadcast in the ATM-LAN 2103. Here, the broadcast is not made in the ATM-LAN 2101 as there is no broadcast channel in the ATM-LAN 2101.

DETD At the IWU 2111, the relaying of the cells to the IWU 2112 is carried out by using the ATM connection 2161 for broadcast in the ATM-LAN 2103. At the IWU 2112, the cells transmitted from the ATM connection 2161 for broadcast are outputted to the broadcast channel of the ATM-LAN 2103, so as to realize the broadcast through the broadcast channel in the ATM-LAN 2103.

DETD On the other hand, as for the cells broadcasted at the terminals in the ATM-LAN 2103, the cells are transmitted to the IWU 2111 by using the ATM connection 2161 for broadcast which is set up between the IWUs 2112 and 2111 by the IWU 2112. In addition, the cells may be transmitted to the CLSF 2121 by using the ATM connection 2151 for broadcast which i set up between the IWU 2111 and the CLSF 2121 by the IWU 2111.

DETD By this method, the transmission and reception of the broadcast cells can be realized without loading the CLSF 2121, the ATM-LAN 2101 in which the CLSF 2121 is contained, and the ATM-LAN 2102 to be tunnelled.

DETD It is noted that, in the above description, the state of being directly connected at the ATM layer can be equivalently expressed as a state of being able to transmit the cell without carrying out the AAL (ATM Adaptation Layer) processing. In addition, in the above description, the address data at the network layer can be replaced by the address data at the CL (Connection-Less) layer, i.e., the upper

layer of the AAL if desired.

CLM   What is claimed is:

1. An **ATM** communication system, comprising: a plurality of
networks, including **ATM** networks and a destination side
network and containing a plurality of terminals, the plurality of
networks inter-networking with each other, the destination side network
containing a destination terminal; and a plurality of connection-less
service function means for managing connection-less datagram
transmission in the plurality of networks, the plurality of
connection-less service function means including a destination side
connection-less service function means which is associated with the
destination side network; wherein the connection-less datagram
transmission from each terminal of the plurality of terminals to the
destination terminal is performed by obtaining a connection identifier
for identifying an **ATM** connection connected to the destination
side connection-less service function means, and by transmitting a
datagram from said each terminal to the destination side
connection-less
service function means through the **ATM** connection identified
by the obtained connection identifier.

2. The system of claim 1, wherein the destination side network is an
ATM network and the connection-less service function means is
provided in each **ATM** network separately.

3. The system of claim 1, wherein the **ATM** connection is set up
between said each terminal and the destination side connection-less
service function means.

4. The system of claim 1, wherein the **ATM** connection is set up
between a source side connection-less service function means associated
with a source side **ATM** network containing said each terminal
and the destination side connection-less service function means.

6. The system of claim 4, further comprising: inter-networking means
provided in the **ATM** networks for inter-networking the
ATM networks, for setting up the **ATM** connection
between the source side connection-less service function means and the
destination side connection-less service function means.

8. The system of claim 1, wherein the destination side connection-less
service function means terminates the **ATM** connection to
analyze the datagram transmitted from said each terminal and relays the
datagram in the destination side network to the destination terminal.

10. The system of claim 1, wherein the connection identifier is
obtained
by using an **ATM** layer address of the destination side
connection-less service function means at said each terminal.

11. The system of claim 1, wherein the connection identifier is
obtained
by using an **ATM** layer address of the destination side
connection-less service function means at a source side connection-less
service function means associated with a source side network containing
said each terminal.

12. The system of claim 1, further comprising; inter-networking means
provided in the **ATM** networks for inter-networking the
ATM networks, for setting up the **ATM** connection
between said each terminal and the destination side connection-less
service function means, which is not terminated over the
inter-networking means.

13. The system of claim 1, further comprising: **address**

resolution server provided for each **ATM**
 network f● processing an **address resoluti**● request
 from said ●ach **ATM** network by relaying the **address**
resolution request to another **address**
resolution server for another **ATM** network
 when a target of the **address resolution** request does
 not belong to said each **ATM** network, and returning information
 indicative of the connection identifier of an **ATM** connection
 which is connected to the destination side connection-less service
 function means, to said each **ATM** network.

 16. The system of claim 1, wherein the **ATM** networks are given
 in forms of **ATM-LANs**.

 17. The system of claim 1, wherein the connection identifier is given
in
 terms of VCI/VPI value specifying the **ATM** connection.

 18. The system of claim 1, wherein the **ATM** networks are
 arranged in a hierarchical network topology.

 19. The system of claim 1, wherein the **ATM** networks are
 arranged in a flat network topology.

 20. A method for **ATM** communication in an **ATM**
 communication system formed by a plurality of networks, including
ATM networks and and containing a plurality of terminals, the
 plurality of networks inter-networking with each other, the destination
 side network including a destination terminal, and a plurality of
 connection-less service function means for managing connection-less
 datagram transmission in the plurality of networks, the plurality of
 connection-less service function means including a destination side
 connection-less service function means which is associated with the
 destination side network, the method comprising the steps of: obtaining
 a connection identifier for identifying an **ATM** connection
 connected to the destination side connection-less service function
 means; and transmitting a datagram from each terminal of the plurality
 of terminals to the destination side connection-less service function
 means through the **ATM** connection identified by the obtained
 connection identifier so as to perform the connection-less datagram
 transmission from said each terminal to the destination terminal.

L4   ANSWER 71 OF 85   USPATFULL
PI   US 5633869 19970527
AB   Asynchronous Transfer Mode Local Area Network (**ATM** LAN). The
      ATM LAN is implemented as a set of **MAC** entities which
      share a common group address space for the purposes of establishing
      multicast connections. Each station has one or more **ATM**
      MAC entities per physical connection to an **ATM**
      network. The network **ATM** LAN service provides the station with
      ATM LAN configuration information needed for **ATM**
      MAC operation. Included in this information is the number of
      ATM LANs the network has configured for that station.
SUMM   Title: METHOD AND APPARATUS FOR REACTIVE CONGESTION CONTROL IN AN
       ASYNCHRONOUS TRANSFER MODE (**ATM**) NETWORK

SUMM   Title: CONCURRENT MULTI-CHANNEL SEGMENTATION AND REASSEMBLY PROCESSORS
       FOR ASYNCHRONOUS TRANSFER MODE (**ATM**)

SUMM   In the above-identified application CONCURRENT MULTI-CHANNEL
       SEGMENTATION AND REASSEMBLY PROCESSORS FOR ASYNCHRONOUS TRANSFER MODE (
       ATM) an apparatus for concurrently processing packets in an
       asynchronous transfer mode (**ATM**) network is described. Packets
       that are to be transmitted are segmented into a plurality of cells,
       concurrently for a plurality of channels, and the cells are transmitted
       over an asynchronous transfer mode (**ATM**) channel. Cells
       received from the asysnchronous transfer mode (**ATM**) channel
       are reassembled into packets concurrently for the plurality of
channels.

SUMM   The present invention is an Asynchronous Transfer Mode Local Area
       Network (**ATM** LAN). The **ATM** LAN is implemented as a
       set of **MAC** entities which share a common group address space
       for the purposes of establishing multicast connections. Each station
has
       one or more **ATM** **MAC** entities per physical connection
       to an **ATM** network. The network **ATM** LAN service
       provides the station with **ATM** LAN configuration information
       needed for **ATM** **MAC** operation. Included in this
       information is the number of **ATM** LANs the network has
       configured for that station.

SUMM   In the present invention, a communication system includes an **ATM**
       network. The **ATM** network has a plurality of ports, each port
       having a unique port address. The **ATM** network includes one or
       more **ATM** switches for connecting sending ports to receiving
       ports.

SUMM   The communication system includes a plurality of stations, each station
       having a unique station address distinguishing the station from other
       stations. Each station is connected to the **ATM** network at a
       port whereby source stations communicate with destination stations.
Each
       station provides packets for transferring information, information
       including a destination station address, for addressing destination
       stations. Each station includes a packet converter for converting
       between packets and cells for transfers between stations.

SUMM   The communication system provides **address resolution**
       for determining a port address corresponding to a destination station
       address. The **address resolution** includes multicast

for multicasting the destination station address to a group of stations.

SUMM   The communication system provides management for requesting connections through the **ATM** network connecting sending ports to receiving ports whereby packets are transferred from source stations to destination stations by cell transfers through **ATM** network.

SUMM   **ATM** LANs may are extended by bridging several **ATM** LANs together using transparent **MAC** bridges and routers.

SUMM   The communication system operates with a multi-level architecture, such as the ISO architecture, and Logical Link Control (LLC), Media Access Control (**MAC**) and addressing functions are performed for **ATM** LANs. An **ATM** LAN provides support for the LLC sublayer by means of a connectionless **MAC** sublayer service in a manner consistent with other IEEE 802 local and metropolitan area networks. The **ATM** LAN interface is built on the user-to-network interface for **ATM** and adaptation layers.

SUMM   The communication system including the **ATM** LAN provides the following benefits:

DRWD   FIG. 1 depicts a number of user stations connected together in an **ATM** network system.

DRWD   FIG. 2 depicts the multi-level protocol used to connect two or more stations in the **ATM** network system of FIG. 1.

DRWD   FIG. 3 depicts the network layer and the data link layer connected to a **ATM** interface in the **ATM** network system of FIGS. 1 and 2.

DRWD   FIG. 4 depicts details of the **ATM MAC** sublayer and the **ATM** interface for stations of FIGS. 1 and 2.

DRWD   FIG. 5 depicts details of the **ATM** LAN **Server** and the **ATM** interfaces of the network of FIGS. 1 and 2.

DRWD   FIG. 6 depicts three **ATM** LANs configured on a three-switch **ATM** network.

DRWD   FIG. 7 is a representation of the details of the **ATM MACs** of stations S0, S1, S2 and S3 from FIG. 6.

DETD   In FIG. 1, an **ATM** network system is shown in which two or more computer stations 10 are interconnected by an **ATM** network 11 for network communication. The stations 10 include the station S0, S1, . . Ss designated 10-0, 10-1, . . . , 10-s. The **ATM** network system of FIG. 1 employs, for example, the top six of the seven OSI model layers. The OSI model physical layer 1 is replaced with a **ATM** interface which operates in an asynchronous transfer mode (**ATM**) in accordance with the B-ISDN protocol.

DETD   In FIG. 2, the **ATM** network 11 connects, by way of example, the S0 station 10-0 to the S1 station 10-1. The S0 station 10-0 includes the top six OSI layers, namely, the application layer [0, 7], the presentation layer [0, 6], the session layer [0,5] and the transport layer [0,4]. The layers 7 through 4 in FIG. 2 are designated as the higher layers and operate in the conventional manner for the OSI model.

DETD   In FIG. 2, the S0 station 10-0 includes the network layer [0,3] and the data link layer, [0, 2]. The data link layer [0,2] includes the logical link control (LLC) sublayer and the media access control (**MAC**) sublayer. The **MAC** sublayer in the data link layer [0, 2] connects to a **ATM** interface 13-0. The **ATM** interface 13-0 operates in accordance with the B-ISDN protocol defined by the CCITT.

DETD   In FIG. 2, the S1 station 10-1 has the higher layers including the application layer [1,7], the presentation layer [1,6], the session layer [1,5] and the transport layer [1,4]. The S1 station 10-1 also includes

the network layer [1,3] and the data link layer [1,2] that connects to the **ATM** interface 13-1. In FIG. 2, the **ATM** interface 13-0 for the S0 station 10-0 and the **ATM** interface 13-1 for the S1 station 10-1 connect to a **ATM** switch 13' in the **ATM** network 11. The **ATM** interfaces 13-0 and 13-1 and **ATM** switch 13' operate in accordance with an **ATM** architecture for **ATM** communicationn. The **ATM** LAN communication is under control of an **ATM** LAN **server** 12 in the **ATM** network 11.

DETD S1　In FIG. 2 each of the higher layers in the S0 station 10-0 and in the station 10-1 function in a well known manner in accordance with the OSI model. Also, the network layer [0, 3] in the S0 station 10-0 and the network layer [1, 3] in the S1 station 10-1 conform to the model OSI

The　data link layer [0,2] in the S0 station 10-0 and the data link layer [1,2] in the S1 station 10-1 have OSI compatibility. The compatibility with the OSI model at the data link layer enables the **ATM** network system of FIGS. 1 and 2 to be compatible with other local area networks and other networks that conform to the OSI model from layer

[2]　and above. Below the OSI layer [2], the communication and connections are compatible with the B-ISDN model of the CCITT.

DETD　In FIG. 3, the data link layer [2] includes the LLC sublayer and the **MAC** sublayer. The LLC sublayer includes the Logical Link Control (LLC) 19 which is conventional in the data link layer of the OSI model.

DETD　The data link layer [2] also includes the **MAC** sublayer which as a component of the data link layer [2]. The **MAC** sublayer typically may include other **MAC** sublayers in accordance with the standards IEEE 802.3, 802.4, 802.5, 802.6 and FDDI. **ATM** LANs are, therefore, capable of interoperating with a wide variety of media. **ATM** LANs interoperate with all IEEE 802 Local Area Networks and Metropolitan Area Networks using transparent bridges and routers. Stations connected to **ATM** LANs communicate with stations connected to any IEEE 802 LAN or MAN via a bridge.

DETD　In accordance with the present invention, the data link layer [2] also includes a new **ATM MAC** sublayer 22 analogous to the other **MAC** sublayers 23. The **ATM MAC** sublayer 22 differs from the other **MAC** sublayers 23 in that the **ATM MAC** sublayer 22 communicates with the **ATM** switch 13 for **ATM** communication.

DETD　In FIG. 3, the **ATM MAC** sublayer 22 includes one or more **ATM MACs** including, for example, **ATM** **MAC** 0, **ATM MAC** 1, . . . , **ATM** **MAC** M designated 21-0, 21-1, . . . , 21-M respectively. Each of **ATM MACs** 21-0, 21-1, . . . , 21-m defines an **ATM** local area network (**ATM LAN**). The **ATM** **MACs** of the **ATM MAC** sublayer 22 connect between the logical link control 19 and the **ATM** interface 13-0. The control of which of the stations (like the stations 10-0, 10-1, . . . , 10-s) are serviced by particular ones of the **ATM** **MACs** 21 of FIG. 3 is determined by the station management 20 within the ATMMAC sublayer 22. Other stations (or the same stations)

may　also be serviced by other local area networks such as Ethernet under control of the other **MAC** sublayers 23.

DETD　In FIG. 3, the **ATM MAC** sublayer is capable of servicing the communication requirements of the stations 10-0 through 10-s of FIG. 1 in one or more **ATM** LANs. Stations can be switched from one **ATM** LAN to another **ATM** LAN under control of station management 20 without requirement of modifying the physical connection to the station. For this reason, the **ATM** LANs are virtual LANs.

DETD　In FIG. 4, further details of the ATMMAC sublayer 22 and the **ATM** interface 13-0 of FIG. 3 are shown.

DETD   In FIG. 4 the **ATM MAC** sublayer includes the station
       managemen⬤) and the **ATM MACs** including t⬤
       ATM MAC 0, . . . , **ATM MAC** M
       designated as 21-0, . . . , 21-M.
DETD   In FIG. 4, the **ATM MAC** 0 includes the multicast
       address resolution 24, the unicast **address**
       resolution 25, the frame 26 and the connection management 27.
DETD   In FIG. 4, the **ATM** interface 13-0 includes the signaling
       protocol 28 in the control plane, the **ATM** ADAPTATION LAYER
       (AAL) 29, the **ATM** layer 30 and the physical layer 31.
DETD   In FIG. 3, the higher layers [7,6,5,5] and [3] are conventional while
       the data link layer [2] includes the LLC sublayer and the **ATM**
       MAC sublayer to implement the Asynchronous Transfer Mode Local
       Area Networks (**ATM** LANs). Such an implementation is provided
       with newly defined Media Access Control (**MAC**) including
       addressing protocols. The **ATM** LAN provides support for the LLC
       sublayer by means of connectionless **MAC** sublayer service in a
       manner consistent with other IEEE 802 local area networks (LAN) and
       metropolitan area networks (MAN). The **ATM** LAN interface is
       built on the user-to-network interface for the **ATM** layer and
       the **ATM** adaptation layer (AAL).
DETD   An **ATM** LAN includes a set of **MAC** entities which
       share a common group address space for the purposes of establishing
       multicast connections. Each station has one or more **ATM**
       MAC entities per physical connection to an **ATM**
       network. The network **ATM** LAN service provides the station with
       ATM LAN configuration information needed for **ATM**
       MAC operation. Included in this information is the number of
       ATM LANs the network has configured for that station.
DETD   The user-to-network interface at the LLC and **MAC** levels is
       defined for the **ATM** LAN Architecture in a manner analogous to
       other Data Link Layer architectures.
DETD   _____

1.3 **ATM** LAN Functionality
An   **ATM** LAN has the following characteristics:
addressing-
           all LANs connected by **MAC** bridges use 48
           bit addressing
unicast-   all stations can send frames to any other
           station in the LAN
duplication-
           frames are not duplicated
broadcast- all stations can broadcast to every other
           station in a LAN
multicast- any station can send to any group address
           and any station can register to receive frames
           for any group address
promiscuity-
           any station may chose to receive all
           frames with group destination addresses

_____

DETD   1.4 **ATM** LANs
DETD   An **ATM** LAN is a local network having a set of stations which
       share a common group address space for the purpose of establishing
       multicast connections. An **ATM** LAN is implemented using
       services of **ATM** LAN **MAC**, **ATM** signaling and
       ATM Adaptation Layers. Stations may participate in more than one
       ATM LAN. **ATM** LANs may be bridged together using
       MAC bridges.
DETD   **ATM** LANs are sometimes called Virtual LANs because they are
       not limited by the limitations of any physical media characteristics. A
       single underlying **ATM** network may support many **ATM**
       LANs. A station with a single **ATM** interface may be connected
       to many separate **ATM** LANs. There are no inherent limitations

in the **ATM** LAN protocol itself to restrict either the physical
extent or ● number of stations in a parti●ar **ATM** LAN.
Practical limitations, such as multicast traffic, usually limit the
size

and scope of **ATM** LANs.
DETD **ATM** LANs interoperate with a wide variety of media.
    ATM LANs can interoperate with all IEEE 802 Local Area Networks
    and Metropolitan Area Networks using transparent bridges and routers.
    Stations connected to **ATM** LANs are able to communicate with
    stations connected to any IEEE 802 LAN/MAN connected via bridge.
DETD   2 **ATM** LAN Architecture
DETD   An **ATM** LAN includes a set of procedures and protocols which
    work together to provide the services found in IEEE 802 LANs. The AAL
    and **ATM** protocols defined by CCITT are augmented by the
    ATM LAN **MAC** layer which maps unacknowledged
    MAC PDUs (**MAC** Protocol Data Units) onto unacknowledged
    AAL PDUs transmitted over virtual connections provided by the
    ATM physical layer. The **ATM MAC** manages
    connections using an **ATM** signaling protocol.
DETD   2.3 Station **ATM** LAN **MAC**
DETD   Each station has one **ATM** LAN module per physical **ATM**
    interface. Each **ATM** LAN module provides **MAC** services
    via one or more **ATM MAC** entities. The **ATM**
    LAN **server** provides the **ATM** LAN **MAC** with
    configuration parameters.
DETD   _____

2.3.1 **ATM MAC** Functions
The **ATM MAC** layer provides the following functions:
ATM LAN Configuration-
        determines the number of **ATM**
        LANs which have been configured
        for the station and the operational
        parameters needed to establish multi-
        cast connections for each **ATM** LAN.
MAC PDU Framing-
        MAC SDUs (Service Data Units) are
        encapsulated in an AAL specific
        framing.
Address Resolution-
        IEEE 802. 48 bit **MAC** addresses are
        mapped onto E.164 **ATM** addresses.
Connection Management-
        establishes and releases virtual
        connections for transmission of **MAC**
        PDUs (Protocol Data Units) and
        reception of frames addressed to reg-
        istered group (multicast) addresses.
Multicast Service-
        protocol and procedures are defined
        for transmission and reception of
        frames with group addresses. The
        network provides unreliable delivery
        via multicast service. The interface
        to the multicast service is AAL
        specific. The interface to be used is
        determined by configuration
        management.
2.3.2 **ATM MAC** Entity Service Interface
The **ATM MAC** entity provides the following service
interface to **MAC** users
Primitive   Parameters

_____

M.sub.-- UNITDATA.request
        destination address
        source address

```
                       mac service data unit
M.sub.-- UNITDATA.indication
                       destination address
                       source address
                       mac service data unit
M.sub.-- REGISTER.sub.-- ADDRESS
                       group address
M.sub.-- UNREGISTER.sub.-- ADDRESS
                       group address
M.sub.-- REGISTER.sub.-- ALL
M.sub.-- UNREGISTER.sub.-- ALL
```

DETD   2.4 **ATM** Adaptation Layer
DETD   2.5 **ATM** Signaling Protocol
DETD   The **ATM LAN** signaling protocol contains a subset of the
        functions in Q.93B. It provides the following services:
DETD   2.6 **ATM LAN Server**
DETD   The **ATM LAN server** provides configuration and
        multicast services. It provides operational parameters for each
    ATM LAN in which each **ATM** station is configured.
        Membership in **ATM** LANs is controlled via policies implemented
        by the **server**. These policies may vary between **ATM**
        LAN providers. The **ATM LAN** configuration protocol defines the
        information provided by stations with which **servers** may
        implement policies. Two policies which can be implemented are "port
        based configuration" and "station based configuration". The **ATM**
        LAN **server** may use the physical cabling to determine LAN
        membership. This is called "port based configuration". Alternatively,
        the **ATM LAN server** may use station **MAC**
        addresses to determine LAN membership. This is called "station based
        configuration". The same station to **server** protocol is used in
        either case. The station is not affected by the configuration policies
        implemented. When requesting **ATM** LAN configuration parameters,
        the station always provides its **MAC** address(es).

DETD   _____

STATION TABLE
(VLAN MEMBERSHIP)
VLAN   **MAC**.sub.-- ADDRESS

VLAN 1	**MAC**.sub.-- Add[0](S1), **MAC**.sub.-- Add [1](S1), **MAC**.sub.-- Add [5](S5) . . .
VLAN 2	**MAC**.sub.-- Add[2](S2), **MAC**.sub.-- Add [6](S6) .
VLAN 3	**MAC**.sub.-- Add[0](S1), **MAC**.sub.-- Add [3](S3), **MAC**.sub.-- Add [4](S4) . . .

PORT TABLE
(VLAN ASSOCIATION)
Port Addresses [s/p#]   VLAN

PA [2,2], PA [2,3], PA [2,4], PA [2,5]	VLAN [3]
PA [2,6], PA [2,7], PA [2,8], PA [2,9]	VLAN [2]
.	.
.	.
.	.
PA [2,3], PA [3,4]	VLAN [3]
.	.
.	.
.	.

DETD   Each station establishes a VC to an **ATM LAN server**

for each physical interface. A well known group address is used. If redundant ATM LAN **servers** are providing configuration and multicast service, this service is transparent to the
ATM station. The **servers** agree amongst themselves which ones will serve any particular station. The **servers** may elect to distribute responsibility for multicast service over several **servers**. This election is transparent to the station.

DETD   3 **ATM** LAN Configuration Management

DETD   A station may belong to one or more distinct **ATM** LANs. The station will then have been configured with one or more **MAC** entities each having a unique **MAC** address.

DETD   At power-on, the station establishes a VC to the network **ATM** LAN **server**. The station ATMMAC sends a configuration enquiry to the **ATM** LAN **server**. The enquiry contains the station's **MAC** address, alan.sub.-- **mac**.

DETD   _____

```
struct alan.sub.-- req { /* configuration request */
u.sub.-- char       alan.sub.-- proto;
u.sub.-- char       alan.sub.-- pdu.sub.-- type;
u.sub.-- short      alan.sub.-- seqnum;
struct atm.sub.-- addr
                    alan.sub.-- mac;
};
```

DETD   Using the unique **MAC** address, alan.sub.-- **mac**, the
ATM LAN **server** determines the number of **ATM** LANs configured for that station and the configuration for each connected **ATM** LAN. A configuration response is sent to the station.

DETD   The configuration response contains one alans.sub.-- parms per
ATM LAN. For each **ATM** LAN the configuration manager activates an **ATM** **MAC** entity. The parameters in the alan.sub.-- parms element control the configuration parameters of each
ATM LAN "tap".

DETD   Each **ATM** LAN `tap` is described by the following parameters. The alan.sub.-- config and alan.sub.-- update messages contain one or more alan.sub.-- parms structures.

DETD   _____

```
struct alan.sub.-- parms {
int                 alan.sub.-- version;
int                 alan.sub.-- aal;
struct atm.sub.-- addr
                    alan.sub.-- port;
struct atm.sub.-- addr
                    alan.sub.-- mcast.sub.-- base;
struct atm.sub.-- addr
                    alan.sub.-- lan.sub.-- uid[ ];
int                 alan.sub.-- num.sub.-- mcast;
u.sub.-- short      alan.sub.-- mid;
u.sub.-- short      alan.sub.-- mtu;
};
```

DETD   The alan.sub.-- aal parameter specifies which AAL is used for multicast frames. Currently defined values are 4 and 5 for AALs 4 and 5 respectively. The alan.sub.-- port is the port address from which VCs are setup for this **ATM** LAN. The **ATM** LAN
server may specify different port addresses for different taps or may specify the same for all. The **ATM** **MAC** entity treats this E.164 address as an unstructured bit string.

DETD   The **ATM** LAN manager allocates a range of E.164 group address space for each **ATM** LAN. The alan.sub.-- mcast.sub.-- base is E.164 group address which is used in conjunction with alan.sub.-- num.sub.-- mcast (the number of group addresses allocated to the

ATM LAN) to map IEEE 802.1 group addresses onto the E.164 group address space. AAL and multicast service parameters are protocol specific.

DETD   AAL multicast service requires that multicast AAL PDUs be transmitted using multiplexing identifiers, (MIDs), provided by the **ATM LAN server**. This allows multicast service to be provided via replication functions often found in **ATM** switch fabrics. Each **ATM MAC** entity is assigned a LAN unique MID for transmission and must reassemble AAL using the full 10 bit MID.

DETD   Each **ATM LAN** is assigned a globally unique identifier, alan.sub.-- lan.sub.-- uid. This is a 128-bit name created by the **ATM LAN server**. The **ATM LAN server** provides alan.sub.-- parms structures for the requested **MAC** addresses. If the station requests configuration parameters for two **MAC** addresses which belong to the same **ATM** LAN, two identical alan.sub.-- parms elements are returned.

DETD   Once the **ATM MAC** entities have been created, the configuration manager periodically sends keep alive frames on the configuration SVC. If the configuration SVC is released the configuration manager destroys the **ATM** LAN entities it created. If after some number of retries the **ATM** LAN **server** does not respond to keep alive packets, the configuration manager will release the configuration SVC and destroy **ATM MAC** entities.

DETD   _____

Configuration Acquisition Protocol State Machine

State	Event	Actions	Newstate
Inactive			
	Activate	Setup Request Start timer C1	Wait for Setup Conf
Wait for			
	Release Ind	Setup Request, Start timer C1	Wait for Setup Conf
Setup Conf			
	Setup Conf	Config Request, Start Timer C2	Wait for Setup Conf
Wait for			
	Timeout	Config Request, Increment Retries	Wait for Setup Conf
Setup Conf			
	Max retries	Release, Setup Request	Wait for Setup Conf
	Config Resp	Activate MAC Entities	Active
Any state			
	Deactivate	Deactive active	Inactive
.linevert split.Active		MAC entities, Release configuration VC	
	Release Ind	Setup Request, Start timer C1	Setup Request, Start timer C1

DETD   4. **ATM LAN MAC**

DETD   The **ATM MAC** maps IEEE 802.1 flat 48 bit addresses to
       60 bit hierarchical E.164 **ATM** addresses by the **address
       resolution** function. Individual IEEE 802. addresses are mapped
       into port addresses via the **ATM Address
       Resolution** Protocol, **ATM** ARP. Group IEEE 802.1
       addresses are mapped to **ATM** group addresses using a fixed
       algorithm.

DETD   Once an **ATM** address is determined, the **ATM** signaling
       protocol is used to establish a virtual connection. The connection is
       either a unicast connection or a multicast connection depending upon
       whether the **ATM** address is an individual or group address.
       Connection management is responsible for establishing and clearing
these
       connections.

DETD   **ATM** LAN uses the same **MAC** framing as 802.6.
       ATM LANs use 48 bit **MAC** addresses to enable
       interoperability with 802 LANs via **MAC** bridges. As shown in
       the following table, addresses are encoded as byte quantities as per
       802.6.

DETD   Two types of addresses are used in an **ATM** LAN, station
       MAC addresses and **ATM** (or port) addresses. Both types
       of addresses may either be individual or group addresses.

DETD   **MAC** station addresses identify individual stations connected
       to an **ATM** LAN. Station addresses are 48 bit universally
       administered 802.1 **MAC** addresses. These **MAC**
       addresses enable interoperability with 802.1D LAN **MAC** bridges.
       Station addresses are used as **MAC** frame source or destination
       addresses.

DETD   **MAC** group addresses are used to address frames to multiple
       destination stations on an **ATM** LAN. Group addresses are used
       to set up virtual connections to multiple destination stations without
       knowledge of those stations' individual addresses. They are used to
       provide multicast and broadcast services. Broadcast is a a specific
       instance of multicast with all stations receiving frames with well
       defined group address, specifically all 1's. Group addresses are 48 bit
       universally or locally administered 802. **MAC** addresses. The
       group address with all bits set to one is the broadcast address.

DETD   **ATM** Port addresses or port addresses or **ATM**
       individual addresses identify physical ports on switches. They are
       hierarchical 60 bit E.164 addresses dynamically assigned by the
network.
       Each virtual connection has a port address for at least one endpoint.
       Port addresses are used in **ATM** ARP and Signaling PDUs.

DETD   **ATM** group addresses (or multicast port addresses) identify an
       ATM level multicast group. They are used in signaling PDUs.

DETD   _____

Address Type		Padding	Address
ATM port address	110x	no padding	60 bits
ATM group address	111x	no padding	60 bits
MAC station address	1000	12 bits	48 bits
MAC group address	1000	12 bits	48 bits

_____

x indicates whether the address is publicly or privately administered

DETD   4.3.2 **ATM LAN** Multicast
DETD   In an **ATM LAN**, multicast capability is provided by the
        multicast **server** which is part of the LAN **server**.
        Stations use that service by establishing virtual connections to the
    server using the multicast base **ATM** address provided
        in the configuration parameters (alan.sub.-- parms). The multicast base
        address is a privately administered group E.164 address. Virtual
        connections with a group **ATM** address at one endpoint are
        multicast VCs. When setting up a multicast VC the station may request
        transmit only access so that it will not receive frames transmitted on
        that VC.
DETD   IEEE 802.1 48 bit addressing provides for up to 2.sup.46 possible group
        addresses all registered by various stations in one LAN. Few **ATM**
        networks could support 2.sup.46 virtual connections. To bridge this gap
        in service offering and network capability, each **ATM** LAN is
        configured to support a small (typically 100s) number of multicast
        circuits. This number is exported in the alan.sub.-- parms
configuration
        element. Each **ATM MAC** entity is also provided with a
        multicast base address which is treated as a 64-bit integer. These two
        numbers are used to map many 48-bit IEEE group addresses to fewer
    ATM group addresses which are then used to setup multicast
        connections. If alan.sub.-- num.sub.-- multicast is zero, then the
        48-bit group address is added to alan.sub.-- mcast.sub.-- base.
        Otherwise the 48-bit group address is treated as a 16 most significant
        bits of the 48-bit group address are Exclusive-Ored into the 32
        least-significant bits, the result is divided by alan.sub.-- num.sub.--
        mcast and the resulting remainder is added to alan.sub.-- mcast.sub.--
        base. In either case, the result value is used as a group address to
set
        up a multicast connection for that group address.
DETD   Each **ATM MAC** entity maintains a list of group
        addresses for which its users have requested it receive frames. Each of
        these group addresses is mapped onto a **ATM** group address when
        the **MAC** entity is given is alan.sub.-- parms information, that
        is, when it becomes active. There after, the **ATM MAC**
        entity will maintain a multicast connection for each port address
        derived from the above computations. Note, several **MAC** group
        addresses may map onto one group port address. In this case, only one
        connection is maintained for those **MAC** group addresses. If the
        network releases a multicast connection, the **ATM MAC**
        entity will re-establish another one.
DETD   The **ATM MAC** entity will always maintain a multicast
        connection for the group port address derived from the broadcast
    MAC address.
DETD   4.3.4 Transmission of Multicast **MAC** PDUs
DETD   When an ATMMAC entity is presented with a M.sub.-- UNITDATA.request
with
        a group destination address it maps the group **MAC** address to
        the group **ATM** address, and transmits the **MAC** PDU on
        the connection established to that port address. If no connection is
        already established, the frame is queued until one is established.
        Multicast connections setup solely for the transmission of multicast
        PDUs are aged in the same fashion as those setup for unicast PDUs.
DETD   4.3.5 Reception of Multicast **MAC** PDUs
DETD   The group destination addresses in received **MAC** PDUs are
        checked against the list of registered group addresses. If the group
        addresses are not registered, the frame is dropped. This dropping is
        necessary because transmitters may map **MAC** group addresses
        onto a multicast connection established to register other group
        addresses.
DETD   Multicast connections established for registered group addresses are
not
        aged. They are not released until the last **MAC** service users
        want to receive frames addressed to any of the group addresses mapped

onto that connection.

DETD The **ATM M** entity maintains reference cou on the
number of MAC service users which have registered a group
address. A reference count on the multicast connection is maintained
for
each **MAC** group which maps onto the connections group
ATM address.

DETD Stations connected to multicast VCs can receive frames from many
sources
simultaneously. The multiplexing identifier (MID) in the ALL4 SAK
header
is used to correctly reassemble these frames. MIDs are unique within a
given **ATM** LAN. The LAN **server** assigns a unique MID
to each port address.

DETD Up to 1023 stations may be connected to an **ATM** AAL 3/4 LAN.
Each station has a globally unique 48-bit address per **ATM** LAN.
Each station is assigned one MID per **ATM** LAN (local port
address to the station) to be used when transmitting frames on
multicast
VCs. Stations may not transmit more than one frame simultaneously on
multicast VCs with the same local port address. Each station implements
MAC level address filtering for frames received on multicast
VCs.

DETD Each station has a multicast filter which is used to filter frames
received on broadcast VCs. This filter may be implemented in hardware
or
software. The filter is necessary because each **ATM** network
provides limited multicast service and stations may broadcast unicast
frames.

DETD AAL 5 does not provide for multiplexing frames on a single VC
simultaneously. The mid field in the alan.sub.-- parms structure is
ignored. There is no limit on the number of stations (or **ATM**
MACs) which may belong to an AAL 5 **ATM** LAN.

DETD 4.4 **ATM Address Resolution** Protocol

DETD Individual IEEE 802.1 **MAC** addresses are mapped into port
addresses via the **ATM Address Resolution**
Protocol (**ATM** ARP). Once the port address is determined the
ATM signaling protocol is used to establish a virtual
connection.

DETD 4.4.1 **ATM** ARP Operation

DETD Stations connected directly to **ATM** LANs will, conceptually,
have address translation tables to map **MAC** addresses (both
station, and group addresses) into virtual connection identifiers. The
MAC-to-port table, provides mappings from **MAC**
addresses to port addresses.

DETD The **MAC** transmission function accesses this table to get next
hop port address given destination station address. This table is
updated when new station address to port address mappings are learned
via **ATM** ARP and when **MAC** group address to
ATM group address mappings are computed. The entries in the
MAC to port table are updated when **ATM** ARP requests
and replies are received.

DETD When the **MAC** layer is presented with a frame for transmission,
it looks up the destination address in the station to port address
table. If an entry is found, connection management selects the
appropriate virtual connection upon which the frame should be
transmitted.

DETD If no entry is found, a new entry is allocated for that **MAC**
address. If the **MAC** address is a group address, an **ATM**
group address is computed using an AAL specific function. This
operation
permits the broadcast VC to be established without sending **ATM**
ARP requests. Mapping individual **MAC** addresses to port
addresses is accomplished by broadcasting an **ATM** ARP request
for the **MAC** addresses to all stations connected to the

ATM LAN. The ATM ARP request carries the senders
MAC and port address mapping. All stations receive the request.
The station with the specified MAC address responds with an
ATM ARP reply. The responder updates its MAC-to-port
table using the information in the request. The reply carries both the
responders' and the requestors MAC and port addresses. When
the requestor receives the ATM ARP reply, it updates its
port-to-MAC address table.

DETD _____
MAC to Port entry
Station Address 48
                    Next Hop Port Status
Bit 802.1 MAC   Address E.164

_____

DETD   The requesting station must transmit MAC frames on broadcast
        connections until it receives responses to its ATM ARP
        requests. It may then set up a connection using the port address in the
        reply. Usually, the responder sets up the connection before replying.
DETD   The ATM ARP function times out entries in the MAC
        -to-port table when they have been idle for some time. Connection
        management is notified when entries in the MAC-to-port table
        are added, updated or deleted. Connection management notifies
        ATM ARP when connections are established and released. Entries
        in this table are deleted when an SVC establishment to the port address
        fails. They are deleted when the connection corresponding to an entry
is
        released.
DETD   4.4.2 ATM ARP PDUs
DETD   ATM ARP requests and replies are encapsulated in 802.2 LLC and
        the appropriate AAL for the connection upon which they are sent.
        ATM ARP requests are always broadcast. Therefore they are
        encapsulated in the AAL used for multicast connections. ATM
        ARP replies are usually sent on point to point connections. The
        ATM MACs negotiate the AAL to be used for that
        connection. The reply is then encapsulated in 802.2 LLC and the
specific
        AAL framing.
DETD   The ATM ARP messages are:
DETD   _____
/*
 *   ATM Address Resolution Protocol.
 */
struct atm.sub.-- arp {
u.sub.-- short
            aa.sub.-- llp; /* lower layer protocol */
u.sub.-- short
            aa.sub.-- ulp; /* upper layer protocol */
u.sub.-- char
            aa.sub.-- llp.sub.-- len;
u.sub.-- char
            aa.sub.-- ulp.sub.-- len;
u.sub.-- short
            aa.sub.-- msg.sub.-- type;
u.sub.-- char
            aa.sub.-- sender.sub.-- port[8];
u.sub.-- char
            aa.sub.-- sender.sub.-- mac[6];
u.sub.-- char
            aa.sub.-- target.sub.-- port[8];
u.sub.-- char
            aa.sub.-- target.sub.-- mac[6];
};
/* aa.sub.-- msg.sub.-- type' s */
#define ATM.sub.-- ARP.sub.-- REQUEST 1

DETD   The aa.sub.-- ulp.sub.-- len and aa.sub.-- llp.sub.-- len fields are
always 6 and 8 respectively. The aa.sub.-- ulp field is set to 16. The
sender **mac** and port addresses are set to the sender's
Mac and Port addresses for request and non-proxy reply messages.
The aa.sub.-- send.sub.-- **mac** field in proxy replies contains
the aa.sub.-- target.sub.-- **mac** from the corresponding
request. The aa.sub.-- target.sub.-- **mac** is always set to the
Mac address needing resolution in requests and it is set to the
requestor's **Mac** address in replies. The aa.sub.--
target.sub.-- port is undefined in requests and in replies it contains
the aa.sub.-- sender.sub.-- port from the corresponding request. The
recipient of a reply verifies that the aa.sub.-- target.sub.-- port
corresponds to one of its own port addresses.

DETD   Once a **MAC** address has been resolved to a **ATM**
address a connection to the station receiving frames for that
MAC address can be set up and those frames can be transmitted
directly to that station rather than broadcast. Connection management
is
responsible for defining the connection establishment and release
policies. The **ATM** signaling protocol is used to establish
connections for **ATM** LAN **MAC** frames. A specific upper
layer protocol identifier is reserved for **ATM** LAN **MAC**
frames.

DETD   Connections are established when an Unacknowledged Data Request needs
to
be transmitted to a **MAC** address for which a to-**ATM**
address mapping is known, but no connection to that **ATM**
address, is established (or emerging). It is possible for two
MAC entities to simultaneously establish connections to each
other. When connection management receives connection setup SDU from
ATM signaling, it checks to see if a connection to the peer port
address already exists. If another connection exists (or is being
established), the connection initiated from the lower port address is
released. Thus there will never be more than one connection established
between two **ATM** **MAC** entities.

DETD   While a connection is being setup, frames which would be transmitted on
that connection once it is established must be queued or dropped.
Frames
should not be broadcast. At least one frame must be queued.
Implementations may chose to queue more. Once the connection is set up,
any queued frames are transmitted. The first frame transmitted on a
connection initiated by a station must be the **ATM** ARP response
for the an **ATM** ARP request.

DETD   Currently, distinct qualities of service may be defined for **ATM**
MAC PDUS.

DETD   Connections for which there is no **MAC**-to-**ATM** address
mapping are held for the product of the number of **ATM** ARP
retries and retry interval and then released. The **MAC**-to-
ATM address mappings are aged separately.

DETD   When **ATM** ARP deletes all the translations to a specific
ATM address, all connections to that **ATM** address are
released.

DETD   When a connection is released, the **ATM** ARP function deletes
all **MAC** to **ATM** translations for that connection's
remote **ATM** address.

DETD   Frame Reception Stations are responsible for performing filtering of
incoming frames. Unicast addressed frames for other stations will be
received on the broadcast VC. Multicast frames for unregistered
multicast addresses may be received on multicast VCs. These frames are
not passed up to the **MAC** service user.

DETD   4.7 **Address Resolution** and Connection Establishment
Example

DETD   In this example, the steps are described that are required for one
        station, called Lyra, to deliver a **MAC** UNITDATA SDU to another
        station, called Altera, assuming neither station has had any prior
        communication. It is assumed that both stations are part of the same
    ATM LAN. These steps are only required for the initial
        transmission from Lyra to Altera. Additional **MAC** PDUs may be
        transmitted on the connection setup by these steps until either station
        decides it no longer wishes to maintain the connection. In this
example,
        MAC addresses are expressed in xx:xx:xx:xx:xx:xx form where each
        pair of hex digits, xx, is one octet for the address. Port addressees
        are expressed in the same form except that they have 8 octets.
DETD   An **ATM MAC** service user on Lyra provides the
    ATM MAC with an UNITDATA SDU to be sent to station
        address 00:80:b2:e0:00:60. The **MAC** consults its **MAC**
        to port address table, but finds no translation.
DETD   The **MAC** creates an **ATM** ARP request for **MAC**
        address 00:80:b2:e0:00:60. The request contains Lyra's own **MAC**
        and port addresses, 00:80:b2:e0:00:50 and d1:41:57:80:77:68:00:02
        respectively. The **ATM** ARP is encapsulated in LLC/SNAP. The
        destination **MAC** address is ff:ff:ff:ff:ff:ff (the broadcast
        address). The **ATM MAC** recursively invokes itself to
        transmit the **ATM** ARP request.
DETD   The **MAC** address to port address table is searched for the
        broadcast **MAC** address and the corresponding port address is
        obtained, f1:41:57:80:77:68:01:01. The station established a connection
        to this port address when the **ATM** LAN **MAC** entered
        the active state. The **ATM** ARP PDU is encapsulated in an 802.6
        frame and passed to the AAL 4 function along with the MID associated
        with this **ATM MAC** entity for transmission of that
        multicast connection.
DETD   The **MAC** must transmit the **MAC** SDU. In lieu of a
        valid **MAC** address to port address mapping the broadcast
    MAC to port mapping and associated connection are used. The
    MAC SDU is encapsulated in an 802.6 frame and passed to the AAL
        4 function with the MID associated with this **ATM MAC**
        entity for transmission of that multicast connection.
DETD   All the above took place on Lyra. The subsequent steps take place on
        Altera as it receives the **ATM** ARP and the **ATM**
    MAC PDU containing user data.
DETD   The **ATM** ARP is received by all **MAC** entities
        including Altera. The other **MACs** determine that the requested
    MAC address is not theirs and ignore the request. Altera
        determines that its **MAC** address is in the request. Altera
        updates its **MAC** to port address table with Lyra's **MAC**
        and port addresses provided in the **ATM** ARP request. Next an
    ATM ARP reply is constructed using Altera's port and **MAC**
        addresses. This request, in the form of an **MAC** SDU with Lyra's
    MAC address as the destination, is passed to the **ATM**
    MAC entity.
DETD   The **ATM MAC** looks up Lyra's **MAC** address in
        the **MAC** to port address table. It finds Lyra's port address.
        The port to VCI table is searched using that port address. No entry is
        found. Connection management is invoked to establish a connection to
        Lyra. Connection management passes a SETUP request to **ATM**
        signaling. The **MAC** queues the **ATM** ARP response until
        the connection is established.
DETD   Altera **ATM** signaling module sends a SETUP PDU to establish a
        connection to port address d1:41:57:80:77:68:00:02. The upper layer
        protocol (sometimes called upper layer compatibility) is the **ATM**
        LAN **MAC**. (This is not a function of the **ATM**
    MAC. But it is included for illustrative purposes.)
DETD   Next all stations receive the **MAC** SDU containing the user data
        on the broadcast connection. All stations except Altera determine that
        the destination **MAC** address is not theirs and drop the frame.

Altera accepts the frame strips off the 802.5 and LLC/SNAP overhead and passes the frame up to the user function identified by LLC/SNAP.

DETD   At this time, the SDU provided to Lyra's ATM MAC has been delivered to the appropriate MAC user on Altera. However, the MAC entities continue connection establishment and address resolution for subsequent communications between the two stations. The next sequence of operations occurs on Lyra.

DETD   ATM signaling on Lyra receives a connection setup indication from the network. This indication is passed up to the upper layer protocol which in this instance is the ATM MAC.

DETD   The ATM MAC receives a setup indication SDU from signaling. At this point Lyra knows some other station's ATM MAC is trying to setup a connection to it. The port to vci table is searched for a connection to the callers port address. In this case none is found. The connection is accepted by passing a CONNECT SDU to ATM signaling. The MAC starts an idle timer for the connection. Note, that the ATM MAC can not use this connection until an ATM ARP request or response is received indicating MAC addresses for stations accessible via the connection.

DETD   Lyra's ATM signaling transmits a CONNECT PDU to the network. Typically, network communication is bi-directional. Assuming this is the case the MAC service user on Altera has responded to the MAC SDU indication with a MAC SDU request,. The following actions take place on Altera. The ordering of the arrival of MAC SDU and the CONNECT SDU are arbitrary.

DETD   The MAC service user passed the ATMMAC an SDU with a destination MAC address of 00:80:b2:e0:00:50 (Lyra's). The MAC finds the mapping from MAC address to port address learned when the ATM ARP request was received from Lyra. The MAC next finds that it is setting up a connection to Lyra's port address and that the connection is not yet established. A MAC PDU is created from the MAC SDU and queued waiting connection establishment.

DETD   Altera ATM signaling receives a connect PDU. This is passed up to the MAC as a SETUP confirmation. The ATM signaling sends a CONNECT acknowledge PDU to Lyra. The connection is considered established.

DETD   Altera's ATM MAC, upon receiving the SETUP confirmation, transmits all frames which were queued awaiting connection establishment. The ATM ARP reply is the first frame to transmitted. It is followed by the MAC PDU containing user data.

DETD   At this TIME, address resolution and connection are complete on Altera. Any further frames addressed to Lyra's MAC address will use the new connection. The connection is not established on Lyra. Also Lyra still does not have a mapping for Altera's MAC address. The following actions complete address resolution and connection establishment on Altera.

DETD   The ATM ARP reply is received on the connection which is still being setup. (Note most ATM networks have slower signaling channels than payload channels. Typically the ATM ARP response will be received prior to the CONNECT acknowledge PDU.)

DETD   The MAC enters Lyra's MAC address to port address mapping in the MAC to port table. At this point any MAC UNIT-DATA requests will be queued until the SETUP complete indication for the connection is passed up from ATM signaling.

DETD   The MAC PDU containing user data from Lyra's MAC users is received. The 802.6, LLC and SNAP headers are removed and a MAC UNITDATA indication is passed up to the appropriate MAC service user.

DETD   Altera's ATM signaling receives a CONNECT.sub.-- ACK PDU. This

moves the connection into established state. The **ATM** signaling function ●ses up a SETUP COMPLETE indica●n informing the **ATM** **MAC** it may ●ansmit on the connection. Connec●on management starts its idle timer for the connection.

DETD   The connection is now established on both stations. One or more **MAC** UNITDATA SDUs have been delivered. The connection will timed out as per local policy decisions.

DETD   **ATM LAN Code Overview**

DETD   The **ATM LAN MAC** code in the appendix is organized by functional components and Operating System (OS) dependencies. The file if.sub.-- **atm**.c contains the routines which contain OS dependencies and which are typically implemented differently for each OS. The unicast unit 25 and multicast unit 24 **address resolution** functions are implemented in the file atmarp.c. The file atmarp.h contains the definitions for the **ATM** ARP protocol and the structures used by atmarp.c to implement the protocol. The file **atm**.c implements the function of connection management unit 27. Those routines interact with the **ATM** signaling function to establish and release connections. The framing unit 26 function is implemented in the OS specific file if.sub.-- niu.c in the routines niuoutput(), **atm**.sub.-- **mac**.sub.-- input() which encapsulate and decapsulate frames respectively. The station management unit 28 functions are implmenented in **atm** .sub.-- init.c and in parts of the **ATM** signaling unit 28 in the files svc.c, svc.sub.-- utl.c and svc.sub.-- pdu.c. The **ATM** **LAN server** unit 12 functions are implemented in the files lm.c, lm.sub.-- cfg.c, lm.sub.-- mgmt.c and lm.sub.-- util.c.

CLM   What is claimed is:

1. For a communication system including a plurality of ports where each port has a unique port address, where sending ports have sending port addresses, and where receiving ports have receiving port addresses, and where the communication system includes a plurality of stations where each station has, a unique station address distinguishing the station from other stations, a connection to one of said ports for communications between source stations at the sending ports and destination stations at the receiving ports, packet means for providing packets for transferring information, said information including a destination station address for addressing one or a group of said destination stations, and packet converter means connected to said packet means for converting between packets and cells for transfers between stations; an apparatus comprising: connection means for connecting said sending ports to said receiving ports, **address resolution** means for determining a particular one or more of said receiving port addresses corresponding to said destination station address, said **address resolution** means including multicast means for multicasting said destination station address from a particular one of said source stations to a group of said destination stations, said multicast means including, response means for providing said particular one or more of said receiving port addresses corresponding to said destination station address, and reply means for transmitting said particular one or more of said receiving port addresses to a sending port; and connection management means connected to receive said one or more receiving port addresses from said **address resolution** means for requesting connections through said networking apparatus connecting said sending ports to said receiving ports whereby packets are transferred from source stations to destination stations by cell transfers.

6. In the system of claim 1 wherein said connection means includes a single **ATM** switch.

9. For a communication system including a plurality of ports, including sending ports and receiving ports, where each port has a unique port address, where sending ports have sending port addresses and receiving

ports have receiving port addresses, and including a plurality of
stations where each station has, a unique station address distinguishing
the station from other stations, a connection for an **ATM**
network at one of said ports whereby source stations at the sending
ports communicate with destination stations at the receiving ports,
packet means for providing packets for transferring information where
the information includes a destination station address for addressing
one or a group of said destination stations, packet converter means
connected to said packet means for converting between packets and cells
for transfers between stations, an apparatus comprising: one or more
ATM switches for connecting said sending ports to said receiving
ports for communications through said one or more **ATM** switches
to form the **ATM** network, **address resolution**
means for determining a particular one of said receiving port addresses
corresponding to said destination station address, said **address
resolution** means including multicast means for multicasting said
destination station address from a particular one of said source
stations to a group of said destination stations, wherein said group of
destination stations that receive the multicast destination station
address constitutes a local network, connection management means
connected to receive said particular one of said receiving port
addresses from said **address resolution** means for
requesting connections through said **ATM** network connecting
said sending ports to said receiving ports whereby packets are
transferred from source stations to destination stations by cell
transfers through said **ATM** network, local network management
means for controlling which of said stations are included within said
group of destination stations that receive the multicast destination
station address.

15. For a communication system including a plurality of ports, including
sending ports and receiving ports, where each port has a unique port
address, where sending ports have sending port addresses and receiving
ports have receiving port addresses, and including a plurality of
stations where each station has, a unique station address distinguishing
the station from other stations, a connection for an **ATM**
network at one of said ports whereby source stations at the sending
ports communicate with destination stations at the receiving ports,
packet means for providing packets for transferring information where
the information includes a destination station address for addressing
one or a group of said destination stations, packet converter means
connected to said packet means for converting between packets and cells
for transfers between stations, an apparatus comprising: one or more
ATM switches for connecting said sending ports to said receiving
ports for communications through said one or more **ATM** switches
to form the **ATM** network, identification means for identifying
a plurality of groups of stations, each group constituting a local
network of the stations in the group, **address
resolution** means for determining a particular one or more of
said receiving port addresses corresponding to said destination station
address, said **address resolution** means including
multicast means for multicasting said destination station address from a
particular one of said source stations to a group of stations
constituting a local network including the source station identified by
said identification means, wherein said multicast means includes,
response means for providing said particular one or more of said
receiving port addresses corresponding to said destination station
address, reply means for transmitting said particular one or more of
said receiving port addresses to a sending port through said **ATM**
network, connection management means connected to receive said receiving

port addresses from said **address resolution** means
for requesting connections through said **ATM** network to connect
said sending ports to said receiving ports whereby packets are
transferred from source stations to destination stations by cell
transfers through said **ATM** network.

17. In the system of claim 15 wherein said management means includes
means for transferring configuration parameters between stations and
said **ATM** network.

18. In the system of claim 15 wherein said management means includes
means for transferring multicast configuration parameters between
stations and said **ATM** network.

20. In the system of claim 15 wherein said said one or more **ATM**
switches comprises a single **ATM** switch.

31. In the system of claim 29 wherein each station has a physical
connection to a pert of said **ATM** network and wherein said
means for adding and deleting operates independently of the physical
connection of each station.

This Page is inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ❑ BLACK BORDERS
- ❑ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ❑ FADED TEXT OR DRAWING
- ❑ BLURED OR ILLEGIBLE TEXT OR DRAWING
- ❑ SKEWED/SLANTED IMAGES
- ❑ COLORED OR BLACK AND WHITE PHOTOGRAPHS
- ❑ GRAY SCALE DOCUMENTS
- ❑ LINES OR MARKS ON ORIGINAL DOCUMENT
- ❑ REPERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☒ OTHER: _hole punched over texts_

**IMAGES ARE BEST AVAILABLE COPY.
As rescanning documents *will not* correct images problems checked, please do not report the problems to the IFW Image Problem Mailbox**